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Curriculum Guideline

Science

Intermediate and Senior Divisions

1987

Part 4

Science

Grades 9 and 10, Advanced Level

Contents

Introduction 3
The Parts of the Guideline 3
Policies and Features That Apply Across the Science Program 3
The Intermediate Division Continuum 5
Full-Credit Courses in Grades 9 and 10 5
Curriculum Emphases 5
Student Activities 6
Safety 6
Sensitive Issues 6
Locally Designed Units 6
Evaluation of Student Achievement 6
Cross References 6

Particular Features of the Grade 9 and 10 Advanced-Level Science Courses 7
Units of Study and Their Time Allocations 7
Balance Over the Two Courses 7
Relationships Between the Advanced- and General-Level Courses 8
Specific Approaches to Be Considered 8
Metric Units in Grades 9 and 10 8

Science, Grade 9, Advanced Level (SNC1A) 9

Core Unit 1: Structure of Matter 10
Core Unit 2: Chemical Change 13
Core Unit 3: Geometric Optics 16
Core Unit 4: Cells and Cell Functions 18
Core Unit 5: Green Plants 21
Core Unit 6: Food and Energy 23
Optional Unit 1: Science in Society 26
Optional Unit 2: Science Project 30
Optional Unit 3: Locally Designed Unit 30

Science, Grade 10, Advanced Level (SNC2A) 31

Core Unit 1: Interactions 32
Core Unit 2: Organisms and Their External Environment 34
Core Unit 3: Organisms and Their Internal Environment 37
Core Unit 4: Heat 39
Core Unit 5: Applied Chemistry 42
Core Unit 6: Magnetism and Electricity 44
Optional Unit 1: Astronomy 47
Optional Unit 2: Waste Management 50
Optional Unit 3: Science Project 53
Optional Unit 4: Locally Designed Unit 53

Appendixes 55

A. Science Courses and Their Course Codes 57
B. The Table of Contents of Part 1 58

Introduction

The Parts of the Guideline

This document is Part 4 of a fifteen-part curriculum guideline that outlines the science program for the Intermediate and Senior Divisions in Ontario schools and describes the science courses that can be offered (see the list of courses and their course codes in Appendix A). The term *guideline* refers to the entire set of fifteen parts.

This part must be read and implemented in conjunction with Part 1, *Program Outline and Policy*. When implementing the courses that are described in this document, teachers are to incorporate the many policies and features outlined in Part 1, which will enable them to interpret the overall intent and expectations of the Ministry of Education in the science program. The table of contents for Part 1 is given in Appendix B at the end of this document so that the reader may have ready access to the list of chapters and topics therein.

The provincial science program for the Intermediate and Senior Divisions comprises the courses described in Parts 2 to 15. These come under the framework and policy set forth in Part 1. The entire science guideline consists of the following fifteen parts:

Part 1: Program Outline and Policy
Part 2: Science, Grades 7 and 8
Part 3: Science, Grades 9 and 10, General Level
Part 4: Science, Grades 9 and 10, Advanced Level
Part 5: Science, Grades 9 and 10, Basic Level
Part 6: Science, Grades 11 and 12, Basic Level
Part 7: Environmental Science, Grades 10 to 12, General Level
Part 8: Environmental Science, Grades 10 and 12, Advanced Level
Part 9: Applied Biology and Applied Chemistry, Grade 11, General Level
Part 10: Applied Physics and Technological Science, Grade 12, General Level
Part 11: Geology, Grade 12, General and Advanced Levels
Part 12: Biology, Grade 11, Advanced Level, and the OAC
Part 13: Chemistry, Grade 11, Advanced Level, and the OAC
Part 14: Physics, Grade 12, Advanced Level, and the OAC
Part 15: Science in Society, OAC

The chart on the next page indicates the twenty-eight science guideline courses that may be offered in Grades 7 to 12 and at the OAC level.

Policies and Features That Apply Across the Science Program

Part 1 of the guideline specifies a great number of the policies and features that are to be integrated into the design of the science program in the Intermediate and Senior Divisions. There are too many of these to describe them in full in each of Parts 2 to 15, but the following points will give the reader some idea of the scope that is involved. They include:

- information about the science credits that are required for the earning of the Ontario Secondary School Diploma;
- a list of science courses that are prerequisite to other science courses;
- the policy regarding mandatory student activities in the science laboratory;
- a list of the aims of the science curriculum and the various emphases that may be used to blend these aims with scientific content;
- policy governing time allocations for units of study and the order in which core and optional units may be taught;
- stipulations about locally designed units;
- suggestions about preferred routes that students might take through the science program in a secondary school;
- recommendations related to exceptional students, individualized instruction, life-management skills, career awareness, the role and evaluation of language in science courses, and a balanced perspective on the role of both girls and boys in science;
- recommendations on the introduction and handling of sensitive issues;
- specific suggestions about resources for the teaching of science;
- ideas about different modes of delivering science courses, including the co-operative education mode;

Authorized Science Guideline Courses, Intermediate and Senior Divisions

	Basic Level	General Level	Advanced Level
Grade 7		Science	
Grade 8		Science	
Grade 9	Science (SNC1B)	Science (SNC1G)	Science (SNC1A)
Grade 10	Science (SNC2B)	Science (SNC2G) Environmental Science (SEN2G)	Science (SNC2A) Environmental Science (SEN2A)
Grade 11	Science (SNC3B)	Applied Biology (SBA3G) Applied Chemistry (SCA3G) Environmental Science (SEN3G)	Biology (SBI3A) Chemistry (SCH3A)
Grade 12	Science (SNC4B)	Environmental Science (SEN4G) Geology (SGE4G) Applied Physics (SPA4G) Technological Science (STE4G)	Environmental Science (SEN4A) Geology (SGE4A)* Physics (SPH4A)
OACs			Biology (SBI0A) *Prerequisite* – Biology (SBI3A) Chemistry (SCH0A) *Prerequisite* – Chemistry (SCH3A) Physics (SPH0A) *Prerequisite* – Physics (SPH4A) Science in Society (SSO0A) *Prerequisite – One of:* Biology (SBI3A) Chemistry (SCH3A) Environmental Science (SEN4A) Geology (SGE4A)* Physics (SPH4A)

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*Since the Grade 12 advanced-level geology course described in the guideline (see Part 11) may be taught under the aegis of a geography department as Geology (GGE4A) – note the course-code change – then either Geology (SGE4A) or Geology (GGE4A) may count as a prerequisite to Science in Society (SSO0A).

- policy pertaining to the significant role to be played by measurement and metric units in science courses;
- stipulations related to the treatment of symbols, significant digits, and mathematical problem solving;
- recommendations concerning the roles to be played by calculators and computers in science courses;
- specific directions about safety;
- policy and principles pertaining to the evaluation of student achievement;
- policy regarding differences in the treatment of science courses at the three levels of difficulty;
- many suggestions about implementing the science program.

It cannot be emphasized strongly enough that teachers of science must integrate the policy and recommendations outlined in Part 1 with the teaching of science and cannot simply rely on the course descriptions given in Parts 2 to 15 of the guideline.

The Intermediate Division Continuum

The two courses Science, Grade 7 and Science, Grade 8, together with the science program of Grades 9 and 10, form a continuum that is intended to help students see something of the panorama of science, enjoy the subject, and appreciate its application to their lives and to society in general. This four-year continuum should also prepare many students for further studies in science in their Senior years.

During the Intermediate years the program is intended to provide a diversified approach to the science disciplines and to build on the more unified approach that is characteristic of the Primary and Junior years.

The Grade 9 and 10 advanced-level courses build on the Grade 7 and 8 program and continue to provide students with the opportunity to work for short portions of each course in each of the disciplines: biology, chemistry, physics, and environmental science. This *mosaic* permits variety and diversity but also allows students to note interrelationships among the sciences. Before the end of Grade 10, students should be able to select those science disciplines in which they wish to specialize in the Senior years.

All teachers of science in the Intermediate years should have some familiarity with the subject matter contained in the science courses that they do not teach so they can minimize overlap among courses and ensure that continuity is provided.

In the Grade 9 and 10 advanced-level science courses, the core units and the prescribed number of optional units are to be included. The time allocation for each unit of study should act as a guide in helping teachers devote a proportionate amount of time to each of the units in a course. This is important in view of the continuum from one course to another, and it is essential if students are to be adequately prepared for further studies in science in the Senior Division.

The Grade 7 and 8 science courses, particularly the core units, provide an important preparation for science in Grades 9 and 10, which is usually offered at the basic, general, and advanced levels of difficulty, as well as for environmental science in Grade 10, which may be offered at the general and advanced levels.

Full-Credit Courses in Grades 9 and 10

It is anticipated that most students will take science in Grades 9 and 10, since two science credits are among the compulsory subjects needed to earn the Ontario Secondary School Diploma. In order that the mosaic nature of the Intermediate Division science courses (the inclusion of biology, chemistry, physics, and environmental science) be retained, each of Science, Grade 9, Advanced Level and Science, Grade 10, Advanced Level are to be offered only as a full-credit course within a single school year or semester. It should be noted that any two science guideline courses may be counted towards the compulsory credits required for the diploma. Thus, some students may wish to take *environmental science* rather than *science* in Grade 10. (See also subsection 4.3 of Part 1 of the guideline.)

Curriculum Emphases

It is recommended that teachers organize each of the courses described in this document around a particular curriculum emphasis or set of emphases. Such emphases give the curriculum a special focus that can be introduced in addition to the content and processes outlined in the courses. This approach is discussed in subsection 3.4, "Curriculum Emphases – Blending Curriculum Aims With Content", of Part 1 of the science guideline. In table 2 of that subsection a list of emphases is given. These emphases will enhance the development of the science courses described in this document. A particular emphasis that is stressed throughout an entire course or for one or more units at a time needs to be highlighted so that it becomes a focal or integrating theme.

Student Activities

In each unit of study there is a section entitled "Student Activities". This section indicates the *mandatory* laboratory activities required of students. Teachers may substitute *equivalent* laboratory activities where appropriate. Those activities that are actually to be performed by students themselves are marked with asterisks. If time and circumstances permit, the teacher should encourage students to do some or all of the unmarked activities as well. However, such activities may be demonstrated by a student or the teacher or may be discussed in conjunction with a textbook, film, computer program, or other learning material used as a resource. In any event, the scientific concepts and principles related to such unmarked activities and identified in the objectives of the unit of study shall be considered to be part of the prescribed course.

Generally, the best approach to the teaching of science is to ensure that the content develops directly from related student activities. In each unit of study the skills and processes of scientific work should be presented as the central component, from which the subject matter, applications, and implications emerge.

Safety

Safety awareness must be developed in all science students. Constant attention to accident prevention is to be stressed in all student activities and teacher demonstrations in the laboratory. Section 9, "Safety", in Part 1 of the science guideline contains the following comprehensive subsections:

- Safety in the Laboratory
- Some Recommended Safety Procedures
- Animal Care in Science Courses
- The Safe Use of Plants

In each unit of study, subsection 6, "Safety Considerations", acts as a reminder of some of the safety features that pertain to the unit in question. General reference, however, should constantly be made to the safety section in Part 1. Schools must always remain on the alert in regards to safety and maintain an up-to-date safety-awareness program.

Sensitive Issues

The curriculum outlined in this science guideline places a distinct emphasis on the science-technology-society connection. For this reason scientific applications and societal implications are mandatory components of each unit of study. In addition, Part 1 of the guideline underlines the need to incorporate morals/values education into science courses. Undoubtedly, this will give rise to the discussion of some sensitive issues.

Such discussions are important. Generally, they should be focused and should provide an open forum for the expression of different viewpoints. In this regard teachers of science are urged to familiarize themselves with section 10, "Values in Science Education", of Part 1 of the guideline and to pay particular attention to the principles to be observed when dealing with sensitive issues in the science curriculum. These principles are mentioned in subsection 10.2 of Part 1.

Locally Designed Units

Among the optional units in each of the courses described in this document is one entitled "Locally Designed Unit" (LDU). Such a unit is included to allow teachers, at their own discretion, either to introduce an appropriate new area of science not described in the guideline or to include additional new work that will expand on previous parts of the course.

Evaluation of Student Achievement

In each unit of study described in the courses outlined in this document, subsection 5, "Evaluation of Student Achievement", specifies certain items that must be included in students' term marks (exclusive of formal examinations) when their achievement is evaluated. In most units teachers are required to evaluate students' activities and related laboratory reports. However, the proportion of the mark assigned will vary from one teacher to another. In order that the experimental component of science be emphasized, the overall mark for an entire science course must include at least 15 per cent for the evaluation of student achievement in laboratory skills and reports.

Cross References

In the descriptions of each unit of study in the courses outlined in this document, cross references are provided in parentheses. These are included to provide some examples of the relationships that exist among the parts of the unit.

Particular Features of the Grade 9 and 10 Advanced-Level Science Courses

Units of Study and Their Time Allocations

The following charts provide an overview of the units of study in Grade 9 and 10 science at the advanced level. They also indicate the time to be allocated to each unit.

Science, Grade 9, Advanced Level (SNC1A)

Units of Study		Time Allocations
Core		
1. Structure of Matter		16 h
2. Chemical Change		16 h
3. Geometric Optics		16 h
4. Cells and Cell Functions		16 h
5. Green Plants		16 h
6. Food and Energy		16 h
		96 h
Optional		
One of:		
1. Science in Society	14 h	14 h
2. Science Project	14 h	
3. Locally Designed Unit	14 h	
		110 h

Science, Grade 10, Advanced Level (SNC2A)

Units of Study		Time Allocations
Core		
1. Interactions		16 h
2. Organisms and Their External Environment		16 h
3. Organisms and Their Internal Environment		16 h
4. Heat		16 h
5. Applied Chemistry		16 h
6. Magnetism and Electricity		16 h
		96 h
Optional		
One of:		
1. Astronomy	14 h	14 h
2. Waste Management	14 h	
3. Science Project	14 h	
4. Locally Designed Unit	14 h	
		110 h

Balance Over the Two Courses

The twelve core units in these two years, six in Grade 9 and six in Grade 10, provide a balance among biology, chemistry, physics, and environmental science. The selection of an additional two optional units, one in Grade 9 and one in Grade 10, can complement the core units, and they can be tailored to student needs, teacher expertise, and the local context.

Another form of balance that must be planned is that between content and process. While subject matter is important, hands-on experiences must also constitute a major component of these courses. Students should become familiar with many scientific skills prior to further study in the Senior Division. Students' ability in demonstrating such skills should be assessed as part of the evaluative process.

These science courses at the advanced level relate science to practical, everyday experiences that are familiar to students. The student activities reinforce these practical applications and provide students with the opportunity to develop skills related to problem solving, domestic management, consumer judgement, recreational pursuits, personal fitness, and employment awareness.

Relationships Between the Advanced- and General-Level Courses

These courses at the advanced level are markedly different from the general-level courses in science in Grades 9 and 10. For example, there is greater emphasis on mathematics and on theory at the advanced level. While these courses provide a practical and societal perspective on science, they should also lay the groundwork for students' eventual entry into science courses at university. Problem solving and creative thinking should begin to play a significant role in the Grade 9 and 10 advanced-level courses.

Although teaching approaches and strategies will differ, it is recommended that similar subject material be used at the beginning of both Grade 9 advanced-level science and Grade 9 general-level science. This can be done through a careful selection of topics from the first two core units of the advanced-level course and the first three core units of the general-level course. In this way, students who are doing exceptionally well in the general-level course after a few weeks may have the opportunity to switch to the advanced-level course without much setback in their work. Similarly, students who are finding it too difficult to cope with the advanced-level course may have the chance to switch to the general-level course, which they may find better suited to their abilities and needs. It should be recognized, however, that as the advanced- and the general-level science courses in Grade 9 progress, they will become more divergent in subject matter and academic expectations.

Specific Approaches to Be Considered

The particle model of matter and a simple model of the atom are included to introduce students to the use of models and theories in science as explanatory devices.

Chemical symbols are introduced and used for the particular elements and chemicals that are studied.

The courses include an emphasis on the use of the microscope to observe the structure of plant and animal cells. Everything should be done to provide experiences in microscopy for all students taking these courses.

In the Grade 9 course, optional unit 1, "Science in Society", may be integrated throughout the course to reinforce the various societal implications outlined for each core unit.

In both of the Grade 9 and 10 courses, optional unit 2, "Science Project", follows the same pattern as similar optional units in Grades 7 and 8 and provides students with additional opportunities to increase their skills in the use of scientific processes and problem solving.

Core units 2 and 3 in the Grade 10 course focus on a comparative study of representative protists, invertebrates, and vertebrates. The vertebrate physiology units in the Grade 11 advanced-level biology course are designed to build on these Grade 10 units. This course also provides students with the opportunity to carry out a simple dissection in core unit 3. Emphasis should be placed not only on the development of the skills necessary to do this successfully but also on appropriate attitudes towards living things and the challenge of keeping dissection activities to a minimum.

If optional unit 1, "Astronomy", is selected for inclusion in the Grade 10 course, the teacher will need to do some special advanced planning. The unit requires students to make observations of astronomical phenomena and to keep a log of their observations. Some events that are to be observed occur over fairly long periods of time. Students should be encouraged to observe the night sky frequently, at least a few minutes each week throughout the year. The teacher should note the implications of the following parts of the description of the unit and prepare students for work before, during, and after the actual block of time that is allocated to the teaching of the unit:

- "Student Activities", subsections a, c, e, g, and j
- "Evaluation of Student Achievement", subsections a and c
- "Safety Considerations", subsections a and b
- "Possible Extensions", subsections b, d, and e
- "Some Teaching Suggestions", subsections a-d, h, and i

Metric Units in Grades 9 and 10

Subsection 8.2 of Part 1 of the science guideline contains a list of metric units with which students are expected to be familiar by the end of Grade 10. Teachers of science and mathematics in Grades 9 and 10 should co-ordinate their work to ensure that this objective is achieved, particularly by students who intend to proceed to science courses in the Senior Division.

Science, Grade 9, Advanced Level
(SNC1A)

Core Units

Structure of Matter
Chemical Change
Geometric Optics
Cells and Cell Functions
Green Plants
Food and Energy

(96 hours)

Optional Units

Science in Society
Science Project
Locally Designed Unit

(14 hours)

Core Unit 1

Structure of Matter

Time: 16 hours

Scientific theories provide a framework for understanding the natural world. Students' investigations into the theory of the structure of matter will enable them to understand how the results of experiments can be used to build and refine scientific models and to provide an experimental basis for scientific theories. The activities within the unit will help students to understand the structure and characteristic properties of matter.

This unit may be divided into topics such as the following:

- ▸ Physical characteristics of solids, liquids, and gases
- ▸ Changes of state
- ▸ The particle theory of matter
- ▸ Applications of the particle theory

1. Objectives

Attitudes. Students will be encouraged to develop:

a) curiosity about the structure of and changes in matter (3a, 4b);
b) a respect for the strengths and limitations of scientific theories (3a);
c) an appreciation of the role of models in explaining natural events (8f);
d) a commitment to the application of scientific thinking in dealing with problems (4b);
e) an appreciation of the role of mathematics in scientific work (8d);
f) a commitment to appropriate behaviour during laboratory work;
g) a co-operative attitude when working with others.

Skills. Students will have the opportunity to develop skill in:

a) observing the characteristics of substances and recording observations;
b) measuring mass, linear dimensions, and volume in SI units (2c);
c) manipulating a balance and a graduated cylinder (2c, 2d);
d) constructing a mass-volume graph for a given substance and obtaining information from the graph (2c);
e) calculating the density of a substance (2d, 8d);
f) classifying an observed change of state (2e);
g) observing diffusion and volume changes during dissolving (2f-2i);
h) writing laboratory reports on their investigations into the structure of matter.

Knowledge. Students will be expected to:

a) list some physical properties used to describe matter (2a);
b) list the postulates of the particle theory of matter (8e);
c) use the particle theory of matter to explain some characteristics of solids, liquids, and gases, including diffusion and changes in volume during dissolving (2a, 8e);
d) identify the energy changes associated with changes of state, such as the absorption of heat by a substance during melting (2e);
e) explain the meaning of the following terms: matter, mass, volume, density, diffusion;
f) express mass, volume, and density in SI units (2d, 8d);
g) solve simple density problems, for example, given the mass and volume of a substance, find the density of the substance, using the formula $D = m/V$ (8d);
h) state what a scientific model is and describe how it is used in the context of the particle theory (8e);
i) describe the changes of state that take place in a practical situation, such as a refrigeration system (3c, 8f).

2. Student Activities

Students are to:

*a) observe various substances and describe their colour, odour, hardness, texture, lustre, transmission of light, and shape (8a);
*b) measure the mass of different objects and the volume of regular objects (by direct measurement) and irregular objects (by displacement of water) (5b);
*c) measure the mass and volume of different samples of a substance and plot and analyse a mass-volume graph for the substance (5b, 5c, 8c);
d) measure the mass and volume of another substance and calculate its density (5b, 5c, 8c);

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* See the subsection entitled "Student Activities" on page 6.

e) observe demonstrations of the changes of state (melting, freezing, evaporation, condensation, sublimation) and note the role of energy in each change (6b, 6c);
*f) observe and compare the rates of diffusion of potassium permanganate through hot and cold water (8a, 8e);
*g) observe the changes in volume during the dissolving of salt in water or during the mixing of alcohol in water (8e);
h) observe the diffusion of a gas through air (8e);
i) observe Brownian motion in a gas and a liquid (8e).

3. Applications

a) Knowledge of the characteristics of matter and the theory of its structure is applied in the research and development of new products (e.g., synthetics, paints, waxes).
b) Changes of state are used to shape the earth's raw materials into useful forms (e.g., the casting of iron).
c) The cooling units of refrigerators, air conditioners, and freezers all work on the basis of the cooling effect of evaporation.

4. Societal Implications

a) Refrigeration is beneficial in the transporting and storing of food and helps make a variety of fruits and vegetables available outside of their growing seasons.
b) The disposal of solid, liquid, and gaseous wastes should be carefully monitored to prevent regional pollution as a result of the diffusion of the chemicals.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) written laboratory reports;
b) measurement of mass and volume in SI units;
c) solving of simple density problems;
d) co-operation with others during student activities.

6. Safety Considerations

a) Protective eyewear should be worn and loose hair should be tied back when substances are being heated.
b) The sublimation of substances (e.g., paradichlorobenzene, naphthalene, iodine) should be demonstrated by the teacher in a well-ventilated area.
c) A hot-water bath rather than an open flame should be used to prevent the possibility of a fire during the sublimation demonstration.

7. Possible Extensions

Some students might:

a) observe a demonstration of the boiling of water under normal, high, and low pressures and record the temperature at which the water boils;
b) explain the phenomenon that occurs in terms of the particle theory of matter for each of the following activities: crystal growing, chromatograph separation, the preparation of solutions using different solids and liquids;
c) determine the thickness of a film of oleic acid on water in order to estimate the thickness of an oleic-acid molecule.

8. Some Teaching Suggestions

a) Students should practise making observations and recording them in tables.
b) Students should be taught how to write a report of a laboratory investigation. Activity 2f or 2g can be used as the basis for such a report. The essential components of the report should be the statement of a problem, the description of observations, and the interpretation of the observations. The interpretations can include calculations, graphs, inferences, predictions, generalizations, and conclusions. All laboratory investigations need not require formal reports. For instance, activity 2a can be summarized effectively in a chart, activity 2b in a set of tables, activity 2c by means of a graph, and activity 2d as the mathematical solution to a problem.
c) Students should construct a mass-volume graph of the data collected in activity 2c. Students should conclude that, although the samples have different masses and volumes, they all have a numerically measurable characteristic in common – the ratio of mass to volume. The terms *interpolation* and *extrapolation* could be discussed as well as the assumptions or inferences made in the process of interpolating or extrapolating.

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* See the subsection entitled "Student Activities" on page 6.

d) Density should be defined as "the quantity of matter per unit volume", that is, mass per unit volume. Students should determine the density of a liquid or a solid in the SI-derived unit, the *kilogram per cubic metre.* Opportunities should be provided for students to solve problems on density, but density problems should not be a major focus of the unit.

e) The particle theory should be taught after students study the characteristics of solids, liquids, and gases and complete activity 3e on changes of state. The theory can be used to explain the physical changes that students have observed. In the discussion about the theory, students should be told that theories are made up of a list of postulates, that the postulates are inventions, and that a description of the theory in any form is a model. The model can be pictorial, a physical representation, a word description, or a mathematical expression. Students can use activities 3f to 3i to practise using the particle theory to explain phenomena.

f) Discussions should involve applications of theories. For example, refrigeration can be explained in terms of changes of state and the particle theory.

g) The teacher should ensure that the components of the science curriculum described in Part 1 of the guideline are incorporated into the implementation process, commencing with the first unit in each course. For instance, in this unit:

- the curriculum emphasis (see subsection 3.4 of Part 1) might focus on the nature-of-science emphasis, the skill-development emphasis, or the knowledge-foundation emphasis;
- the importance of sex equity (subsection 6.6 of Part 1) and laboratory safety (subsections 9.1 and 9.2 of Part 1) might be stressed from the very beginning of the course to ensure that both girls and boys share full responsibility for conducting all aspects of laboratory work and that they work co-operatively in maintaining safety awareness;
- a *language* assignment (subsection 7.2 of Part 1) requiring a short, well-worded outline of the kinetic-molecular theory and how it applies to changes of state in a practical situation might be included;
- metric units of length, area, volume, mass, and density can be extended beyond those used in the student activities to include the full list of such units stated in subsection 8.2 of Part 1. For example, the larger units can be introduced by referring to the volume of water in a reservoir, the mass of coal in a coal pile, or the density of oil in a large storage tank. Areas can be introduced by mentioning that, in some instances, volume = area of base × height (or depth); for example, the volume of a reservoir is often stated in hectare metres (ha·m);
- other components mentioned in Part 1 might also be introduced.

Note: This kind of teaching suggestion is given here only and is not repeated in subsequent units. It is included primarily to illustrate the need to integrate components of Part 1 into the courses that are outlined in this document.

Core Unit 2

Chemical Change

Time: 16 hours

This unit is intended to provide students with opportunities to observe a number of chemical changes. This study of chemical reactions will help students understand the difference between elements and compounds and the meaning of *atom* and *molecule*. The investigations in the unit will provide an experimental foundation that establishes a need for modifying the particle model, which is presented in core unit 1, "Structure of Matter". Students will be given an opportunity to develop a model for atomic structure that attempts to explain the behaviour of matter during a chemical change.

This unit may be divided into topics such as the following:

- Classification of substances
- Elements and compounds
- Physical and chemical change
- The structure of atoms (i.e., the Rutherford-Bohr model)

1. Objectives

Attitudes. Students will be encouraged to develop:

a) a commitment to the careful and safe handling of laboratory equipment and chemicals (8b);
b) an appreciation of the need to modify or change scientific models in order to account for new evidence (8g);
c) an awareness of and curiosity about the many chemical changes that they encounter in daily life (3, 4).

Skills. Students will have the opportunity to develop skill in:

a) observing the characteristics of homogeneous and heterogeneous substances (2a);
b) classifying matter according to composition, for example, as homogeneous, heterogeneous, pure substance, solution, element, compound (2a);
c) observing changes in substances when elements combine and when compounds decompose or react with other compounds (2b-2d);
d) recording observations in tables or sentence form during investigations of chemical and physical changes;
e) classifying changes as physical or chemical (8e);
f) developing a model for atomic structure based on experimental work (2f-2h, 8g);
g) formulating a hypothesis from the statement of a problem (2e);
h) distinguishing between observations and inferences (2b-2d).

Knowledge. Students will be expected to:

a) define and correctly use the following terms: homogeneous matter, heterogeneous matter, solution, compound, element, pure substance, classification, electron, proton, neutron, atom, molecule;
b) describe and interpret the evidence for chemical change and physical change and give examples of each (2b-2d, 8d, 8e);
c) describe the splint test for oxygen and hydrogen and the limewater test for carbon dioxide (2b);
d) write word equations for the chemical reactions encountered in this unit;
e) describe the production of and the interaction among electrostatic charges (2f, 8g);
f) discuss Rutherford's gold-foil experiment (8g);
g) describe the Rutherford-Bohr model of the atom and use it to explain the results of Rutherford's experiment, the production of electrostatic charges by friction, the formation of ions and compounds (ionic), and the existence of ions in solutions (8g-8i);
h) write the correct symbol for the elements encountered in this unit and recognize that the symbol represents an atom of the element.

2. Student Activities

Students are to:

*a) observe various samples of matter and classify them as homogeneous or heterogeneous (6b, 8a);
*b) (i) describe the appearance of the elements carbon, magnesium (or steel wool), and oxygen; (ii) test oxygen, using the splint test; (iii) burn each of carbon and magnesium (or steel wool) in oxygen; and (iv) test the products formed in (iii) for the presence of carbon dioxide, using limewater (6a-6d, 8b);
c) observe a demonstration of the electrolysis of water and the testing of the oxygen and hydrogen gases produced by means of the splint test (6c, 8c);
*d) perform experiments to illustrate physical and chemical changes, such as the melting of ice, the crushing of copper (II) sulphate crystals into a fine powder, the reaction of dilute hydrochloric acid with iron filings, the mixing of clear solutions of barium nitrate and sodium sulphate, and the reaction of phenolphthalein with sodium hydroxide solution (6b, 8e);
e) investigate and compare the masses of the reactants and the products of a chemical reaction in a closed system, for example, in the reaction of barium nitrate and sodium sulfate solutions (8f);
*f) produce electrostatic charges by rubbing an ebonite rod with fur and a glass rod with plastic or silk and observe the interactions between like charges and between unlike charges (8g);
g) test the electrical conductivity of solutions of sodium chloride and potassium iodide (8h);
h) conduct flame tests for different substances and explain the results in terms of the Rutherford-Bohr model of the atom (6a).

3. Applications

a) Chemical changes in the body convert food and release energy.
b) Some substances (e.g., organic solvents, ammonia solutions) make good cleaning agents because they react chemically with other substances that tarnish or soil surfaces and fabrics.
c) The rusting and corrosion of metals result from chemical reactions between the metals and the oxygen in moist air.
d) Baking soda is added to the dough in cakes, bread, and biscuits. When the mixture is heated, a chemical change in the baking soda releases bubbles of carbon dioxide, which puff up (leaven) the dough.
e) A knowledge of chemical changes allows scientists to develop many useful products (e.g., medicines, synthetic fibres, cleaning agents, plastics, waxes, paints, perfumes, adhesives).
f) An understanding of the structure of the atom led to the discovery and use of atomic energy.

4. Societal Implications

a) Chemical reactions are involved in the development of a variety of products that have, by and large, improved the quality of life and provided employment for many people. However, the inadequate disposal of by-products and wastes in industry has often led to the pollution of rivers and ground-water supplies and to the formation of acid rain.
b) Rust-prevention techniques stop or slow down the rusting of cars and machinery. This has resulted in economic benefits to users.
c) While nuclear energy has many applications in the field of nuclear weapons and the war industry, it has also been used for the production of other forms of energy for domestic use and for many other peaceful purposes.
d) Certain pollutants (e.g., sulphur dioxide) that undergo chemical changes in the atmosphere produce acid rain.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) observing and recording of changes in chemical reactions;
b) classification of changes as physical or chemical;
c) writing of laboratory reports;
d) use of the Rutherford-Bohr model of the atom to explain experimental observations.

6. Safety Considerations

a) Protective eyewear should be worn and loose hair should be tied back when substances are being heated.
b) Chemicals that are corrosive, poisonous, or reactive should be handled with appropriate precautions.
c) Because hydrogen is explosive and oxygen supports combustion, the splint tests should be done with small quantities of these gases.
d) Students should not look directly at burning magnesium.

7. Possible Extensions

Some students might:

a) investigate the corrosion of different metals and study the different methods of preventing corrosion;
b) investigate the use of the periodic table as a classification scheme in which elements are grouped according to similar characteristics;

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* See the subsection entitled "Student Activities" on page 6.

c) observe the electrolysis of potassium iodide solution and make inferences about the existence of ions and the transfer of electrons at the electrodes;
d) use a variety of library resources and report on one or more of the following:

   - the historical development of the atomic model
   - the discovery of the neutron
   - the electron arrangements in atoms
   - the past and present symbols for elements
   - chemical formulas
   - chemical equations

e) organize and maintain a bulletin board of current articles from newspapers and science magazines related to this unit.

8. Some Teaching Suggestions

a) A large display of matter can be used for activity 2a to provide an opportunity for students to recognize the need to classify matter so that different properties of substances can be easily compared and studied.
b) Activity 2b can be used to show that elements combine to form compounds and to illustrate the effect of combination reactions on the properties of the elements. Safety rules regarding the handling of chemicals and the performing of experiments should be emphasized.
c) In activity 2c students should realize that a compound can be decomposed into simpler substances.
d) Students should record observations and draw inferences for activities 2b and 2c. For example, "When magnesium is burned in oxygen, a bright light and white powder are produced" is an observation; "The white powder is magnesium oxide, and magnesium and oxygen combined to produce it" is an inference. Chemical symbols should be introduced for the elements used, both as an abbreviation and as a representation of an atom of the element.
e) Activity 2d provides an opportunity for students to distinguish between physical and chemical changes. Students should realize that new substances are formed during a chemical change and that one or more of the following usually occur and can be regarded as evidence of a chemical change: change in colour, production of light and heat, formation of a precipitate, production of a gas or gases.
f) Students should make a hypothesis as a part of some investigations. Activity 2e is intended to illustrate the law of conservation of mass, which could be an appropriate extension to this unit. Students should make a hypothesis before they do the experiment. The difference between a law and a theory in science should be discussed here.
g) Activity 2f introduces students to the study of electrostatic charges and provides evidence that should lead them to formulate a reasonable hypothesis about the nature of electrostatic charges. Students' understanding of the role of a model in science, which is introduced in core unit 1, should be reinforced. It should be emphasized that a model is not necessarily something believed to be true; rather, it is a device employed to correlate and explain observations and experimental data. The results of activity 2f cannot be explained in terms of the particle model. A new model is needed to explain the production of negative and positive electrostatic charges by friction and to account for the way in which atoms are joined together (bonded) in a compound as shown in activity 2b. A discussion of the work of Rutherford should lead to the development of a model of atomic structure. Electron clouds should be described as regions in which the electrons might normally be found in order to avoid depicting an electron as a particle moving along a circular path. The model can be used to explain the results of activity 2f. It can also account for the formation of charged particles (ions) when an electrical imbalance is created in neutral atoms. Electrostatic attraction between oppositely charged ions may be thought to be responsible for the formation of molecules. An in-depth discussion of bonding is not required in this unit.
h) Activity 2g should allow students to infer the existence of ions in solutions of sodium chloride and potassium iodide.
i) The results of activity 2h should provide evidence to support the Rutherford-Bohr model of the atom. The terms *electron*, *proton*, and *neutron* should be introduced only as they relate to the Rutherford-Bohr model.

Core Unit 3

Geometric Optics

Time: 16 hours

This unit involves the study of light and its behaviour as it travels from a source to the eye of an observer. Students will recognize a variety of sources of light and will learn how different kinds of media affect the transmission of light. The unit includes activities on the reflection of light from plane and spherical surfaces. Students will perform experiments with prisms and will investigate various colour effects. The title of the unit suggests that geometry is involved. Students are expected to produce precise and meaningful diagrams to represent optical phenomena.

This unit may be divided into topics such as the following:

- Sources of light
- Transmission of light
- Reflection of light
- Plane and spherical mirrors
- Colour

1. Objectives

Attitudes. Students will be encouraged to develop:

a) a sense of satisfaction in drawing neat and accurate geometrical ray diagrams to show the formation of images by mirrors (2e);
b) an appreciation of the role of inferences in science (8b);
c) a respect for the design and care of optical instruments (3e, 3f, 4a).

Skills. Students will have the opportunity to develop skill in:

a) observing images in plane and spherical mirrors (2c, 2e);
b) distinguishing between observations and inferences in investigating shadows and the formation of images in pinhole cameras and mirrors (2a-2c, 2e, 8b);
c) locating images produced by a pinhole camera, a plane mirror, a concave mirror, and a convex mirror (2b, 2c, 2e);
d) making generalizations about the location and characteristics of images produced by plane and spherical mirrors (2c, 2e);
e) drawing ray diagrams to illustrate the following:

- the formation of shadows (2a);
- the formation of an image in a pinhole camera (2b);
- how the eye sees an image in a plane mirror (2c);
- an incident ray of light travelling from an object to a plane mirror and to convex and concave mirrors and the resultant reflected rays of light (2e);

f) drawing to scale ray diagrams of images formed by concave and convex mirrors, given the focal length of the mirror and the location of the object (8d);
g) proposing hypotheses, such as assuming relationships about colour effects (2g, 8f).

Knowledge. Students will be expected to:

a) explain and correctly use the following terms: luminous, non-luminous, incandescent, fluorescent, opaque, transparent, translucent, umbra, penumbra;
b) compare a ray and a beam of light, regular and diffuse reflection, and real and virtual images;
c) list the characteristics of an image produced by a pinhole camera and by a plane mirror (2b, 2c);
d) define and correctly use the following terms: incident ray, reflected ray, normal, angle of incidence, angle of reflection, point of incidence;
e) state the laws of reflection (2d);
f) locate the following on a diagram of a spherical mirror: vertex, centre of curvature, principal axis, focal point, an incident ray and its reflected ray with their normal at the point of incidence;
g) describe the location and list the characteristics of the image formed by a spherical mirror, given the location of the object (2e);
h) describe the dispersion of white light (2f);
i) list the following: the primary colours (additive primaries) and their secondary colours, the primary pigment colours (subtractive primaries) and their secondary pigment colours (2g, 8f);
j) state the secondary colour produced when any two primary coloured lights are mixed (2g, 8f);
k) state the colour produced when any two subtractive primaries are mixed as pigments or as filtered light (2g, 8f);
l) use the subtractive colour theory to explain how filters work (8f, 8g).

2. Student Activities

Students are to:

a) observe shadows and describe them, using the terms *umbra* and *penumbra* (8b);
b) observe the image formed on the screen of a pinhole camera and draw a ray diagram to illustrate the formation of that image;
*c) locate the image produced in a plane mirror and determine its characteristics (5c);
*d) compare the angle of incidence and the angle of reflection when light is reflected from a plane mirror (8c);
*e) locate the image produced by a concave mirror and a convex mirror when an object is at various positions in front of the mirror; in each case, determine the characteristics of the image and draw to scale a ray diagram to illustrate its formation (5c, 8d);
f) use a prism to disperse white light into a spectrum (8e);
g) perform experiments to observe (i) the appearance of coloured pieces of paper when placed separately under red, blue, yellow, and green light; (ii) the colour produced when the primary additive colours (red, green, and blue) are projected onto a white screen so that the colours partly overlap; and (iii) the colour produced when white light is shone through a combination of different-coloured filters (8f, 8g).

3. Applications

a) Translucent glass allows light to enter a building while providing privacy.
b) Transparent and translucent materials are used in architecture and interior decorating to achieve different effects.
c) Plane mirrors can be used to make a room seem larger.
d) Photography depends primarily on reflected light.
e) The reflection of light from plane surfaces is used within binoculars, single-lens-reflex (SLR) cameras, periscopes, microscopes, and other optical instruments.
f) Curved mirrors are used as cosmetic mirrors, as rear-view mirrors in vehicles, and as surveillance mirrors in stores; parabolic reflectors are used in flashlights, car headlights, searchlights, and solar collectors.
g) A colour television picture tube operates on the principles of the additive colour theory.
h) Theatrical colour effects are achieved by additive colour mixing.
i) Subtractive colour mixing is used in the making of paints and dyes.

4. Societal Implications

a) Applications of principles of light and colour have resulted in the production of many devices that have improved scientific techniques as well as the quality and enjoyment of life (e.g., colour television, the high-resolution microscope).
b) A great deal of time and effort is devoted to using light and colour to create desired impressions both indoors and out. The moods of people are often influenced by light and colours.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) laboratory work;
b) written laboratory reports;
c) drawing of ray diagrams of images produced by plane, concave, and convex mirrors;
d) explanations of colour phenomena.

6. Safety Considerations

a) Loose hair and clothing should be tied back if candles are used as light sources. Candles should not be used on inclined surfaces.
b) Flammable materials (e.g., paper) should not be held near lit candles.
c) Students should be advised not to look directly at or touch bright or hot light sources.
d) Approved sources of electric light should be used, and care should be taken in connecting them to or disconnecting them from electrical outlets.
e) Appropriate fire-extinguishing equipment should be readily available if candles are used as light sources.

7. Possible Extensions

Some students might:

a) construct a pinhole camera and use it to take photographs;
b) study the methods that have been used to determine the speed of light;
c) determine the factors that affect the intensity of light;

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* See the subsection entitled "Student Activities" on page 6.

d) construct a Newton's disc to show the recomposition of coloured light into white light;
e) study the phases of the moon and solar and lunar eclipses;
f) read about and report on the perception of colour and light by the eye;
g) study the use of light filters in photography.

8. Some Teaching Suggestions

a) The change of a non-luminous object into a luminous one as a result of an energy conversion may be illustrated by the following examples: the chemical energy in a piece of wood is converted into light and heat as the wood burns; heat energy is converted into light when a piece of steel is heated until it glows; electrical energy is converted into light and heat in a light bulb and in a fluorescent tube as they are lit; food energy is converted into light in fireflies.
b) The formation of shadows should be demonstrated to allow students to infer that light travels in straight lines. Students' understanding of the difference between observations and inferences should be reinforced, and the inference that light travels in straight lines should be used to explain the observations in activity 2a.
c) Students can use activity 2d to discover or verify the first law of reflection of light.
d) An opportunity could be provided for students to predict the location and characteristics of images in plane and spherical mirrors prior to the laboratory study by drawing ray diagrams for various object locations. This would allow students to use the ray diagrams in a predictive role and make them aware of what to expect in activities 2c and 2e.
e) Activity 2f can be used to consolidate and organize students' knowledge about the spectrum of white light.
f) The first part of activity 2g provides an opportunity for students to realize that the colour of an illuminated object depends on the colour of the light that illuminates it and on the pigment that the object contains. In the second and third parts of activity 2g, students can hypothesize about what determines the colour that is seen. The additive and subtractive colour theories could be considered.
g) After the completion of activity 2g, students will be able to predict what colour will be observed as light is passed through combinations of filters.

Core Unit 4

Cells and Cell Functions

Time: 16 hours

The cell is the basic structural and functional unit of life. Cells and groups of cells interact with their environment through the processes of gas exchange, acquiring necessary nutrients and discharging wastes. Cells show a great diversity in structure and function. An understanding of cells provides insight into health and disease, biological research, and genetic engineering.

This unit may be divided into topics such as the following:

- The microscope
- Cell theory
- The typical cell, its parts and functions
- Cell organization and differentiation

1. Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation of the contribution of biological research to our knowledge of living organisms (3b, 3c, 4);
b) an appreciation of the value of modern scientific instruments such as the microscope (3a);
c) an awareness of the complexity of modern cellular research (8a).

Skills. Students will have the opportunity to develop skill in:

a) manipulating a microscope (2a-2c);
b) preparing and staining wet mounts for observation under the microscope (2c);
c) demonstrating the proper care and use of the microscope (2a-2c);
d) observing through a microscope and recording observations by means of drawings (2a-2c);
e) estimating the size of microscopic specimens (2a);
f) calculating the magnification of a microscope (2a);
g) classifying cells as plant or animal according to their characteristics (2b, 2c);
h) recording information about cells and cell processes (2b-2g);
i) making and testing a hypothesis about the direction of water movement by osmosis (2d, 8e).

Knowledge. Students will be expected to:

a) recognize and state the function of the parts of a microscope, including the following: eyepiece, objective lens, stage, focus knobs, diaphragm, nosepiece (2a-2c);
b) describe how to find the magnification of an image formed by a microscope (2a, 8c);
c) state the cell theory (2b, 2c, 8a);
d) label the major parts of a cell on a diagram or model (2b, 2c, 2f);
e) describe and state the function of cell parts, including the following: chromatin, nucleolus, nucleus, nuclear membrane, cell membrane, cell wall, cytoplasm, vacuole, chloroplast, mitochondrion, centrosome;
f) compare plant and animal cells, noting their major structural differences (2c);
g) define *diffusion* and *osmosis* (2d);
h) identify the role of osmosis and cell turgor in the transport of water into and within cells (2d, 8d);
i) describe the process of mitosis, identifying the principal events that occur (2e);
j) describe cell organization by defining *tissues*, *organs*, and *organ systems* and providing examples of them (2f, 2g);
k) use an example to describe cell differentiation (2f, 2g).

2. Student Activities

Students are to:

*a) use a compound microscope to examine several specimens and then measure or estimate the diameter of the field of view of one specimen in the microscope and use this to estimate the actual size of the specimen (6, 8b, 8c);
*b) observe a prepared slide containing cells (e.g., elodea, spirogyra) under a microscope and make a clear, labelled drawing of the cells (6, 8b, 8c, 8f);
*c) prepare and stain wet mounts of a plant and an animal cell (e.g., onion skin, elodea, cheek epithelial cell), observe the cells through a microscope, and make labelled diagrams of the observations (6, 8b, 8c, 8f);
*d) investigate osmosis using either dialysis tubing with starch and iodine or a potato and a sugar solution (8d, 8e);
*e) observe prepared slides of cells (e.g., those of an onion root tip) in various stages of mitosis (6, 8g);
f) study a root tip to observe the zones of cell differentiation and draw and label each area of specialization (6);
g) examine the shape, size, and distribution of cells in various tissues, such as blood, muscle, and bone (6).

3. Applications

a) Microscopy is used in almost all scientific disciplines, including geology, metallurgy, forestry, physiology, medicine, chemistry, and physics.
b) Scientists use their knowledge of cells to study food production, genetics, and the effects of pollutants on organisms.
c) Our knowledge of cell structure and function has contributed to the battle against diseases, as indicated by immunization and the use of antibiotics.

4. Societal Implications

a) As a result of research on cells, human health and nutrition have been improved, and new treatments for diseases have been discovered. Consequently, the average lifespan of humans has increased.
b) Cell cloning as a method of reproduction and genetic engineering as a technique for deliberately altering the chromatin of organisms may have economic, legal, and moral consequences.
c) An understanding of cell maturation and ageing may help humans to control more effectively the ageing process.

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* See the subsection entitled "Student Activities" on page 6.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) use of the microscope;
b) diagrams and charts;
c) laboratory report (at least one);
d) results on a brief, practical test in which they prepare a wet mount and demonstrate how the microscope can be used efficiently to examine a specimen.

6. Safety Considerations

a) Broken glass slides should be stored in a separate, well-marked container for disposal.
b) Care should be taken in regard to electrical cords for microscope illuminators. They should be in good repair and positioned so that students do not trip over them.
c) Students should be informed that stains used in the preparation of microscope slides may also stain paper, clothing, and skin.
d) Students are to wash their hands thoroughly after handling biological materials.
e) When working with body fluids (e.g., saliva in which cheek cells are examined or blood used in microscopy investigations), students must be careful to ensure that such fluids are not transferred, directly or indirectly, from one student to another. Cover glasses and slides should be disinfected by placing them in a 10 per cent solution of water and household bleach for twenty minutes. Students must wash their hands thoroughly with soap and water.

7. Possible Extensions

Some students might:

a) outline the historical development of the microscope by tracing the contributions of Janssen, Galileo, van Leeuwenhoek, Hooke, Hillier, and Prebus;
b) compare the light microscope and the electron microscope with reference to development, structure, operation, and magnification;
c) observe electron photomicrographs of common cell structures;
d) observe a variety of living protozoa under the microscope;
e) do a simple investigation of plasmolysis and develop a theory to explain it.

8. Some Teaching Suggestions

a) The teacher might discuss how a scientist would do cell research today compared with 100 and 300 years ago. This should be a stimulating topic involving a library search or investigation.
b) It should be pointed out that the limited depth of field of microscopes suggests that cells are flat, whereas they are really three-dimensional.
c) Students should include with each cell sketch an estimate of the degree of magnification represented by their actual drawing (drawing size compared to actual cell size as a fraction). The chief purpose of the cell sketches is the promotion of observational accuracy rather than artistic appeal.
d) Students should be given the opportunity to plan the experiment on osmosis, and they should be encouraged to make a hypothesis, record data in tabular and graphic form, and reach a proper conclusion.
e) The teacher should stress that osmosis involves only the movement of water through membranes.
f) The waterweed elodea is an excellent plant to use for microscopic study; it grows abundantly in many Ontario lakes and ponds.
g) Students can build a simple model of the chromosome activity during mitosis, using coloured wool or pipe cleaners.
h) Activities 2f and 2g may be performed either through the use of prepared slides and a microscope or with the aid of a textbook or some other learning material.

Core Unit 5

Green Plants

Time: 16 hours

Green plants are an essential part of our lives. They are a source of oxygen and food and provide us with building materials and fibres for paper and fabric. They also provide beauty and many recreational activities. Our climate is modified when plants hold water in the ground, serve as windbreaks, provide shade from direct sun, and release moisture into the air. This unit will familiarize students with the functioning plant, and the activities will provide opportunities for students to investigate the structure and function of plant tissues.

This unit may be divided into topics such as the following:

- The plant stem
- The plant leaf
- Photosynthesis
- Respiration
- The importance of plants

1. Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation of the need to protect and conserve plants (3a, 4b);
b) an awareness of the economic value of plant products in our society (3d, 4c);
c) a respect for the value of plants as the prime producer of oxygen and carbohydrates;
d) an appreciation of proper conduct in the laboratory and proper care and use of the equipment.

Skills. Students will have the opportunity to develop skill in:

a) using the microscope to observe the characteristics of microscopic plant tissues (2a);
b) hypothesizing about the factors that affect photosynthesis in plants (2b-2d, 8f);
c) observing accurately during scientific investigations (2a, 2b, 2e);
d) drawing conclusions about the role of chlorophyll and light in the process of photosynthesis (2c-2e);
e) predicting the relationship between the structure and function of cells in a plant leaf (2a, 2e);
f) planning and organizing a brief written report (2h);
g) obtaining information from a library or resource centre (2h).

Knowledge. Students will be expected to:

a) describe and state the function of tissues in a plant stem, including the following: xylem, phloem, cambium, epidermis (2a);
b) describe and state the function of tissues in a leaf, including the following: upper and lower epidermis, palisade cells, spongy cells, veins (2a, 2e);
c) identify the structural adaptations of a leaf that aid in photosynthesis (2a, 2e);
d) describe the operation of a stoma (2e);
e) write the word equation for photosynthesis (2b-2e, 8f);
f) describe the role of chlorophyll and light in photosynthesis (2b, 2c, 8f, 8h);
g) recognize and describe simple tests for starch and carbon dioxide (2b, 2f);
h) describe the role(s) of roots, stems, and leaves in the process of photosynthesis (2a, 2b);
i) compare the processes of photosynthesis and respiration (2b-2g);
j) write the word equation for respiration (2f, 2g);
k) outline several uses of plants in society (2h, 3, 4).

2. Student Activities

Students are to:

*a) observe microscope slides of live plant material to identify and draw tissues in a plant stem or a leaf cross section (5a, 6a);
b) observe a demonstration of an experiment that shows the role of chlorophyll in the production of starch in green plants (6b, 6c, 8h);
*c) perform an experiment to demonstrate the role of light in the production of starch in green plants (8a, 8b);
d) perform an experiment to demonstrate that a gas is released during photosynthesis (8a, 8b);

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* See the subsection entitled "Student Activities" on page 6.

*e) make a microscopic examination of stomata, using the lower epidermis of lettuce or geranium leaves, and draw a labelled diagram (5a, 8a, 8e);
f) perform an experiment to demonstrate that respiration in germinating seeds produces carbon dioxide gas (8c);
g) perform an experiment to show that respiration consumes a part of air (8c);
*h) use the resource centre to prepare a written report on the uses of plants in our society (3, 4).

3. Applications

a) Agriculture, one of Canada's most vital industries, usually demands extensive knowledge of the requirements of plants.
b) Large numbers of woody plants are grown from seed each year under controlled conditions for use in reforestation and landscaping.
c) The horticulture industry produces flowers and small plants that are generally used to decorate our environment.
d) Home gardening is an extremely popular pursuit in Ontario.
e) Interior decorators often use plants to modify the environment within buildings. Exterior planting may alter environmental conditions by providing shade and windbreaks.

4. Societal Implications

a) Extensive lumbering and the urbanization of society threaten vast areas of natural vegetation.
b) Our demand for energy sources may lead to the production of methane gas from plants or the burning of vegetation (biomass) to produce energy.
c) The addition of woodstoves to modern homes has resulted in dramatic growth in the wood-fuel industry.
d) The chemical analysis of certain plants has resulted in many useful drugs, including morphine, codeine, digitalis, and quinine. Many plants that have yet to be studied may provide us with valuable medicines.
e) Scientists may develop new varieties of food plants, resulting in increased crop yields.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) drawings made from microscope specimens;
b) laboratory work and reports;
c) written report prepared for activity 2h.

6. Safety Considerations

a) If thin sections of live plant material are being prepared, the student should take appropriate care with the microtome or razor blade used for sectioning.
b) A hot plate should be used to heat the alcohol during the extraction of chlorophyll from a leaf. Alcohol should not be heated over an open flame.
c) Ethyl rather than methyl alcohol should be used to extract chlorophyll. Adequate ventilation should be provided.

7. Possible Extensions

Some students might:

a) use a microscope to study the plant root in cross section;
b) investigate plant tropisms;
c) separate the components of chlorophyll (in activity 2b), using paper chromatography;
d) use a microscope to examine and compare several different leaves or stems;
e) develop chemical equations for photosynthesis and respiration;
f) demonstrate that energy is released when seeds respire in a vacuum bottle;
g) briefly study the nature and role of leaf pigments other than chlorophyll.

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* See the subsection entitled "Student Activities" on page 6.

8. Some Teaching Suggestions

a) If there are facilities in the classroom, a variety of plants may be grown and observed (e.g., coleus, geranium). The plants may also be used for the studies in this unit.
b) Students should be given help in designing at least one of the experiments in this unit. Activities 2c and 2d are particularly suitable in this regard. This will provide opportunities for students to practise controlling variables.
c) Germinating seeds should be prepared in advance by soaking them overnight. Large seeds such as corn, beans, and peas should germinate in one to two days if soaked first.
d) Dry cobalt chloride paper (blue) may be firmly attached to a leaf with a glass slide held by a paper clip. The subsequent release of water vapour through the stomata will cause the paper to turn pink.
e) A thin film of collodian (clear) on an attached plant-leaf surface will demonstrate the presence of stomata. Wherever water is released, a whitish colour will form in a few hours.
f) The results from several of the investigations on photosynthesis should be available before students write the complete equation. They can then use each experimental result to help them design the subsequent experiment until photosynthesis has been fully investigated.
g) The equation for photosynthesis shows glucose production, but the leaf contains large quantities of starch. The reasons for these observations should be discussed.
h) A variegated species of coleus and of geranium should be used to investigate the role of chlorophyll in photosynthesis.
i) The evaluation of student drawings of microscope specimens should focus on the accuracy of the reproduction rather than on the artistic ability of the student.

Core Unit 6

Food and Energy

Time: 16 hours

In our supermarket society we often do not realize how much is involved in the producing, processing, and preserving of food. Science and technology play a critical role in the production of food. It is important that students have some concept of the energy required to place food on supermarket shelves, as well as of the flow of energy through farms and food industries. This unit will introduce students to the constituents, production, processing, and preservation of foods and the relationship between food and energy.

This unit may be divided into topics such as the following:

- ▸ The constituents of food
- ▸ Energy and food
- ▸ Food production
- ▸ Food processing

1. Objectives

Attitudes. Students will be encouraged to develop:

a) a respect for the role of electricity and fossil fuels in the production and processing of food (3c, 4d);
b) an appreciation of the role of science and technology in the production and processing of food (3d, 4c);
c) a concern about the ability of our modern society to meet increasing demands for supplies of food (3c, 4b);
d) a respect for the contribution of many Canadians who work in the production or processing of food (3b, 4d);
e) an awareness of the quantity of energy required to bring food to supermarket shelves (3c, 4b);
f) an appreciation of the need to have all aspects of the food-production chain economically profitable (3b, 3c).

Skills. Students will have the opportunity to develop skill in:

a) classifying foods according to their constituents (2b, 8e, 8f);
b) recording observations from a variety of tests on food enzymes (2c);
c) manipulating laboratory equipment in the food and enzyme tests (2c);
d) interpreting the effects of various environmental factors on plant growth (2e);
e) relating the conclusions from laboratory plant-growth experiments to the growth of food crops (2e).

Knowledge. Students will be expected to:

a) name and describe the major chemical constituents of foods, such as carbohydrates, proteins, lipids, water, vitamins, and minerals (2a, 2b);
b) describe simple tests for the major constituents of food (2b, 8e-8g);
c) define an enzyme and describe the enzyme's role in the release of energy from foods (2c);
d) recognize the areas of nutrient storage in the seed of a food plant (2a);
e) identify the energy source in foods and the relative energy content of various foods (2d);
f) compare the energy required to produce foods derived from plants and animals (3c);
g) recognize the sources of the energy used for food production (3c, 3d);
h) list the major food crops grown in Ontario;
i) recognize the environmental factors that influence the production of food crops (2e, 8b);
j) describe the role of micro-organisms in food production (e.g., the role of rhizobium in nitrogen fixing in legumes);
k) describe the role of micro-organisms in food preparation (e.g., in the preparation of yogurt and cheese);
l) list techniques used for preserving foods (3e, 8c);
m) trace the path of a basic food (e.g., grain, milk) from production through processing and indicate where energy is used (4b);
n) compare the amount of energy obtained from a food to that used to produce and process it (3c).

2. Student Activities

Students are to:

a) examine one or more varieties of seed (e.g., grain or beans) under magnification to observe the areas where nutrients are stored (6a, 6b);
*b) perform tests to detect protein, sugar, starch, fat, and water in several foods, such as milk and dog food (6a, 8e-8g);
*c) perform an experiment to show the effects of enzymes on the digestion of foods (6b);
d) perform an experiment to show that the burning of a food (e.g., peanut, marshmallow) releases energy (6c);
*e) perform investigations to show the effect of a variety of conditions (e.g., light, temperature, fertilizers, soil, water) on the growth of plants (8b);
f) perform an experiment to show the effect of yeast on a sugar solution;
g) observe a demonstration of the production of methane gas through the decomposition of organic material;
h) prepare foods (e.g., cheese, yogurt, bean sprouts) in the laboratory, making accurate observations of the changes that take place (8g);
i) collect information on a field trip (where feasible) to a local agricultural operation or food-processing plant; observe particularly the energy requirements of the operation with regard to such features as producing, harvesting, storing, processing (e.g., cooking, adding preservatives, packaging), and transporting (without deterioration or contamination). If a field trip is not feasible, students are to prepare a library assignment on energy and food processing (5c).

3. Applications

a) An understanding of the constituents of foods can lead to selectivity in choosing foods for a balanced diet.
b) The production, processing, and distribution of food make up one of Ontario's largest industries.
c) There is a direct relationship between the amount of energy required to produce a food and the cost that the consumer must pay for that food.
d) Some new energy sources (e.g., solar energy, methane gas from manure) and new methods of energy conservation are beginning to be used in Ontario food production.
e) A variety of sophisticated and traditional methods of processing and preserving food make it possible to obtain most foods all year round.

4. Societal Implications

a) Research is required to ensure that food-processing techniques do not alter the nutrient value of the constituents of foods.
b) Twelve per cent of the energy used in Canada, largely from non-renewable sources, is used in Canadian agriculture.
c) A great deal of money and scientific research is directed annually into studies of food production and preservation by various organizations, including federal and provincial governments, universities, and private industry.

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* See the subsection entitled "Student Activities" on page 6.

d) The production of adequate food supplies requires the continuous input of energy, fertilizer, water, and a large bank of good farmland. A shortage in the supply of any of these essentials could seriously affect our food supplies.
e) Pesticides and herbicides are used to increase crop yields. They also require energy in their production and can have harmful environmental effects unless carefully controlled.
f) In Ontario, the agrifood industry (which includes a range of activities, from manufacturing agricultural implements to putting food on the table in restaurants) is the second largest contributer, next to the automotive industry, to the gross national product.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) practical laboratory work in determining the constituents of food;
b) written laboratory reports;
c) report on a field trip or library assignment on energy and food processing.

6. Safety Considerations

a) Students should be cautioned not to taste any substance unless instructed to do so by the teacher.
b) Students should wash their hands thoroughly after handling biological matter.
c) Students must wear protective eyewear and must tie back loose clothing when they are heating substances.

7. Possible Extensions

Some students might:

a) quantitatively determine the vitamin C content of various foods;
b) discuss aerobic and anaerobic respiration as methods of converting food into energy;
c) investigate, with the aid of the microscope, moulds that grow on food or that are used in cheese processing; other fungi (e.g., powdery mildew) that decrease food yields could also be studied;
d) determine the effectiveness of enzymes at various temperatures or in different concentrations;
e) grow plants hydroponically and investigate the effects of the addition of specific minerals to the solution nourishing the plants;
f) apply the selective herbicide atrazine to a variety of seedlings in the classroom to show that it will destroy all plants except corn;
g) study the constituents of milk and demonstrate the pasteurization and centrifugation of raw milk;
h) study the operation and energy requirements of essential farm machinery, including both the role of technology and the need for continuous energy supplies in the production of food;
i) study the role of various bacteria (e.g., salmonella, staphylococcus) in the bacterial contamination of food and outline methods of food preservation that control these organisms, with special emphasis on the need for proper care of food in the home.

8. Some Teaching Suggestions

a) This unit could follow an energy emphasis, a food and nutrition emphasis, or an agricultural science emphasis. The variety of objectives and activities gives the teacher some latitude in matching the unit to the school's location and students' backgrounds.
b) As a follow-up to activity 2e, students could relate the major types of soil in Ontario to the food crops grown on each soil. The Ontario Ministry of Agriculture and Food is an excellent source of resource material for this type of study.
c) If growing space permits, a legume such as the soybean could be planted and inoculated with a culture of rhizobium. The root nodules could then be studied microscopically after a few weeks.
d) Part 5, "Food", of the Ontario Ministry of Education publication *Energy in Society: A Resource Guide for Teachers* contains many useful ideas and activities. In addition, the Ontario Ministry of Agriculture and Food publication entitled *Helpful Teaching Resources for Food Systems and Agriculture* and a package entitled *Food and Energy* contain lists of useful resources.
e) The food tests could be performed on a common food first and then repeated on an unfamiliar food such as dog or cat food. The students' success in determining the constituents of unknown foods could be used towards the term mark for this unit.
f) The test for sugars should not be done with non-reducing sugars such as common table sugar.
g) Processed milk cannot be centrifuged or used for cheese making. Any raw milk obtained for these activities will be unpasteurized and should not be tasted.

Optional Unit 1

Science in Society

Time: 14 hours

This unit provides opportunities for students to make informed decisions about social issues that are part of their lives. Such decisions should be tentative and should evolve in an open-ended manner during succeeding years as students mature and gain further insight. A number of issues will be selected for study. Each should have a significant science component and be topical, interesting, and important. The selected issues should be unresolved and should lend themselves to a variety of viewpoints and decisions.

There are many societal issues mentioned in each unit of this course. An excellent way to implement "Science in Society" would be to study one or more of the societal issues raised during the course of each unit rather than examining them in a single block of time at the end of the course. Thus, it is recommended that this unit be integrated with the core units as the year progresses. The activities in this unit are not intended necessarily to involve hands-on laboratory work.

One goal of this unit is to help prepare young people to make rational and ethical decisions. Situations that provide students with practice in information gathering and reasoning should be presented. The emphasis will be placed on the process used to reach a rational decision rather than on the decision itself. Students will gain insight into some of society's specific problems and examine the role of their own values and beliefs in the possible solutions to such problems.

When dealing with social issues, students should realize that the methods of science alone will not solve the problem. The information and techniques provided by the areas of science must be pooled with those provided by the study of law, economics, religion, politics, and technology if a workable solution is to be found. Students should be encouraged to collect and use information from a variety of sources, share with each other through discussion, and scrutinize information for possible bias.

This unit contains teaching suggestions for one sample societal issue from each core unit. However, it is not necessary to use these issues, as there are many other problems that can be related directly to the course.

This unit may be divided into topics such as the following:

- Recognition of an issue and the domains of knowledge involved
- Scientific facts and assumptions, and the limits of science
- Decision-making processes
- Recognition of values and beliefs

1. Objectives

Attitudes. Students will be encouraged to develop:

a) a co-operative attitude in classroom discussions;
b) appreciation for the complexity of societal issues;
c) respect for the role of other disciplines besides science in helping to find solutions to societal problems that are related to science;
d) open-mindedness with respect to others' values and beliefs;
e) respect for the methods of science in the gathering of information to help clarify societal issues;
f) critical-mindedness in interpreting information and searching for bias;
g) confidence in their own ability to discuss social issues and reach a tentative position.

Skills. Students will have the opportunity to develop skill in:

a) gathering information about an issue;
b) searching information for validity and bias;
c) recognizing moral aspects of an issue;
d) brainstorming and co-operating in group discussions;
e) using a problem-solving model in an attempt to resolve an issue;
f) evaluating several alternative solutions in the light of personal beliefs.

Knowledge. Students will be expected to:

a) identify and name attitudes that are characteristic of scientific endeavour (e.g., curiosity, honesty, perseverance, critical-mindedness);
b) describe some of the limitations of scientific processes and information;
c) describe several applications of science to the solution of societal issues in Canada;

d) distinguish between the roles of pure and applied sciences in the solution of problems;
e) recognize several major societal issues in Canada in which science plays a significant role;
f) recognize some essential scientific facts on which societal issues are based (e.g., road salt in water increases the corrosion rate of some metals, the mass of green plants affects the rate at which carbon dioxide is removed from the air, sulphur dioxide reacts with rainwater to form an acid).

2. Sample Issues

The sections "Student Activities", "Applications", and "Societal Implications", normally included in the descriptions of other units of study, are combined here to provide examples of how one societal issue from each core unit can be expanded and integrated as the basis for this "Science in Society" unit.

Core Unit 1: Structure of Matter

Topic: Applications of the particle model – diffusion

Issue: The presence and distribution of potentially harmful substances in air and water

Strategy: Case study
a) After students have acquired a basic understanding of the process of diffusion, they can examine, from sources assembled by the science teacher and the teacher-librarian, a situation in which potentially harmful particles have entered the air or water and diffused into a larger area. The particles chosen should be of local interest and may include freon, PCBs, dioxin, mercury, carbon dioxide, sulphur dioxide, or chlorine. The students should plan how they are to report on their case study.
b) Scientific evidence outlining why the particles are believed to be harmful and any conflicting opinions can then be considered.
c) Students can identify groups with a special interest in the situation, the knowledge base on which these groups may make their decisions, and the values that the groups reflect.
d) The class can be involved in discussions to explore how these groups have interacted to help raise the issue. Some students may be assigned to role-play particular individuals who are involved with the issue, and the class can thereby gain an insight into a different set of beliefs. The attitudes of an industrial worker, a taxpayer, a politician, or the parents of a young child may be explored.

Core Unit 2: Chemical Change

Topic: Physical and chemical changes

Issue: The conflict between the harmful and beneficial effects of a chemical or physical change

Strategy: The evaluation of alternatives – problem solving
a) A conflict should be identified. For instance, in the winter, salt spread on roads helps make them safer to drive on but hastens the corrosion of metals in cars, deteriorates the roads, and damages nearby plants. Students can gather appropriate information and data with the help of the teacher-librarian.
b) Working individually or in groups, students can suggest alternative courses of action that might resolve the conflict. For each alternative the possible consequences can be identified.
c) Students can evaluate each consequence as positive or negative and record that decision. Each student can clarify which of his/her own values helped influence the decision.
d) Students can compare all of the alternatives through a general discussion, weighing the pros and cons and choosing the best alternative.

Core Unit 3: Geometric Optics

Topic: An application of advanced optics

Issue: Should satellites be used to photograph the earth from space?

Strategy: Data collection, evaluation of alternatives, making value judgements
a) Students can brainstorm to come up with as many reasons as possible for photographing the earth from space (e.g., detecting the depth of the oceans, discovering mineral deposits, observing crops, gaining intelligence information).
b) The class can gather data on the process of photographing from space and the potential of the process. The actual purposes to which it is put should be determined. Actual and potentially viable purposes, including those determined through research, can be listed.
c) Individual students can evaluate each purpose and prioritize it numerically, from best to worst, according to their own values.
d) Following the individual exercise, a discussion can be held to point out the variety in the selection of "best to worst" and to emphasize that, in many issues, there appears to be a number of "best" solutions.

Core Unit 4: Cells and Cell Functions

Topic: The cell

Issue: The use of living animals for scientific and medical research

Strategy: The analysis of a moral problem – the controversy that surrounds the use of animals for research

a) Students can collect information from newspapers, periodicals, and the school library resource centre to determine how animals are used in research.
b) They can identify the dilemma. Many people feel a responsibility for the care of animals, but others feel that animal research will help solve human problems.
c) Evidence can be found to support each position. Students should weigh both sides, thus acquiring some sympathy for both arguments.
d) Through discussion or brainstorming, students can attempt to define courses of action that would reduce or resolve the problem.
e) They can predict the consequences if the new approaches were followed and can evaluate the alternatives. A solution or set of solutions can be proposed and justified on moral or legal grounds.
f) Finally, the solution or each solution in a set may be evaluated in terms of questions such as the following: Is it realistic? Could it be implemented?

Core Unit 5: Green Plants

Topic: Use of green plants

Issue: What are the environmental effects of burning biomass and fossil fuels?

Strategy: Case study

a) Students can be reminded of the exchange of gases that occurs in the living green plant and can contrast it with the gas exchange that occurs when plants or fossil fuels are burned.
b) Through a guided classroom exercise and library search, using a variety of materials, students can look at some of the harmful effects of carbon dioxide buildup as a result of burning. The greenhouse effect, desertification, and the destruction of wildlife habitats can be included.
c) Students can study some of the ways by which science and technology predict, monitor, and explain these effects.
d) The limitations of science in preventing this problem can be pointed out. Students can propose actions that could stop or reverse the harmful effects of burning plants or plant products and then suggest reasons why our society has not taken such action.

Core Unit 6: Food and Energy

Topic: Food source

Issue: The use of animals for food

Strategy: Cognitive moral development – a strategy that encourages students to improve the quality of their moral reasoning

a) Students can consider one small part of the energy flow through a food system and the problem it creates.
b) The problem might be stated as follows: "Most Canadians enjoy eating meat. To produce 1 kg of animal protein requires many kilograms of plant protein in animal feed (20 kg of plants to produce 1 kg of beef). In many countries people cannot get enough protein from any source. Therefore, how can we justify wasting plant protein in animal feed when humans need it?"
c) Students can respond to questions or statements using techniques such as rank ordering, a values continuum, forced choice, or open-ended statements. They can take a position on the original problem and then describe a problem that would result from their position (e.g., If Canadians stopped eating meat, many people would lose their jobs.).
d) The class can be divided into small groups whose members share a similar position. Each group can develop a list of reasons that justify its position and rank-order the three or four best reasons.
e) Each group can then report to the class. The teacher may record and classify the positions and reasons that are presented. For a conclusion, the teacher may have the class answer general questions such as the following: What action should be taken by Canadians from the point of view of a beef farmer? How would a family in the Third World act? Is there any way of resolving this particular issue in Ontario?

3. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit, whether it is implemented as a stand-alone unit or integrated with the core units, is to be based on three or more of the following:

a) a scrapbook dealing with scientific social issues with a short summary written by the student that indicates the source and nature of the issue raised in the material;
b) participation in small- and large-group discussions and work;
c) a list of viable alternative courses of action that might help resolve an issue;
d) an analysis of the issue in order to identify the science component;
e) a written or oral report on a Canadian inventor or scientist who has helped provide a solution for a scientific social issue;
f) the identification, in any given issue, of the sides involved and the conflicts in values that prevent an easy resolution;
g) a series of posters, advertisements, or commercials that promote the values for the courses of action desired by the groups taking a position on an issue.

4. Possible Extensions

Some students might study other relevant "Science in Society" issues that relate to the core or optional units, such as the following:

- control of the weather
- acid rain
- breathalyzer (blood) tests
- disposal of hazardous wastes (Note: "Waste Management" is an optional unit in Science, Grade 10, Advanced Level.)
- health effects of interior fluorescent lighting
- energy collection by large solar mirrors in space
- control of ageing
- cell cloning
- organ transplants
- test-tube reproduction
- testing procedures for the effect of drugs, medicines, and food additives on humans
- social and personal effects of smoking
- chemical spraying of crops and forests
- wood alcohol as a fuel
- use of farmland for other purposes than farming
- energy costs of agricultural systems
- energy costs in processing and packaging foods
- use of marketing boards in the control of food prices

5. Some Teaching Suggestions

a) Several films involving scientists such as Darwin, Galileo, or Oppenheimer could be used to enhance historical perspectives and show that society's values change.
b) This is an excellent unit in which to bring in guest speakers from another department or school, or from the community. Students could analyse the different viewpoints presented by the guests.
c) Self-analysis reaction sheets and values-continuum lines could be used to help students think about their own beliefs and values.
d) The teacher should encourage a classroom atmosphere that is free of ridicule or criticism so that students can express their opinions and beliefs freely.
e) Much of the evaluation for this type of unit is subjective and depends on the careful observation of each student's participation. One good way to do this is to make a checklist on which each objective from the unit is itemized. Then, as group activities occur, the appropriate behaviour can be rewarded.

Optional Unit 2

Science Project

Time: 14 hours

This unit provides students with the opportunity to apply and further develop their skills in the processes of science while studying topics of special interest. It is recommended that such topics relate to issues of scientific concern and that some experimental work be an integral part of the unit.

The general framework within which this unit is to be implemented is described in optional unit 1, "Science Project", in the Grade 7 science course. (See Part 2 of the guideline.)

Since the opportunity to engage in a science project exists in each of Grades 7 to 10, teachers are advised to develop lists of topics that are appropriate, to display some project reports that are exemplary, and to try to ensure that the projects developed by a student over the Intermediate Division years are diverse and developmental so that the student gains experience with a variety of topics.

Optional Unit 3

Locally Designed Unit

Time: 14 hours

This unit is to be designed at the local level as desired. It can be used to introduce a new area or topic of science not described in this guideline or to incorporate additional objectives that will expand a part or parts of the course already covered. Examples of new areas or topics that might be considered include the following:

- Agriculture
- Astronomy
- Careers in science
- Continuity
- Forestry
- Fungi and simple plants
- Horticulture
- Machines
- Mechanics
- Separation of substances
- Vibrations and waves

This unit may provide an excellent opportunity for students to engage in independent study on a topic in science that is of particular interest and that is approved, monitored, and evaluated by the teacher. Students may work individually or in small groups. Care should be taken not to allow the work to overlap with subject matter in other science courses that students are likely to take. The unit could be started after students have had some experiences in the laboratory and are well aware of accident prevention. If a series of short topics is considered, the topics may be fitted into the course schedule from time to time throughout the semester or year.

It is expected that the local design of this unit will incorporate components similar to those adopted in the core units, namely, objectives, student activities, applications, and societal implications. An outline of the unit is to be included with the school's course of study and kept on file so that it is available to interested students and parents.

Science, Grade 10, Advanced Level
(SNC2A)

Core Units

Interactions
Organisms and Their External Environment
Organisms and Their Internal Environment
Heat
Applied Chemistry
Magnetism and Electricity

(96 hours)

Optional Units

Astronomy
Waste Management
Science Project
Locally Designed Unit

(14 hours)

Core Unit 1

Interactions

Time: 16 hours

The expression "the balance of nature" is a common way of referring to the varied and often complex interactions that occur among plants, animals, humans, and the environment. This unit will help make students aware of these natural relationships. Through an understanding of nature's harmony, they should be better able to understand problems such as endangered species and the effects of human activities on plant and animal habitats. In becoming more aware, they may also become more willing to accept responsibility for influencing environmental decisions.

This unit may be divided into topics such as the following:

- ▸ Biotic and abiotic environmental factors
- ▸ Trophic levels
- ▸ Populations
- ▸ Communities and biomes
- ▸ Materials and energy flow
- ▸ Succession
- ▸ Human influence on the environment

1. Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation of the sensitivity of ecosystems (3a, 4e, 8a);
b) a respect for the varied roles of plants and animals in the natural environment (3b, 4b, 4e);
c) a concern for the natural habitat of plants and animals (8b, 8c);
d) a respect for quotas and restrictions in fish and game laws and the management of land by humans (3b, 4d, 8a);
e) an appreciation of the natural ecological balance in a major Canadian ecosystem (2i).

Skills. Students will have the opportunity to develop skill in:

a) recording information about natural ecosystems (2a, 2b, 2h);
b) graphing population changes and prey-predator relationships (2d, 2g);
c) observing some interrelationships in natural communities (2a-2c);
d) interpreting the results of investigations involving laboratory simulations of natural communities (2c, 2g);
e) evaluating environmental issues (2b, 2h, 2i);
f) classifying common organisms according to their niche (2a);
g) predicting the result of environmental changes on populations and communities (2c, 2h).

Knowledge. Students will be expected to:

a) define and explain ecological terms, including the following: herbivore, carnivore, omnivore, producer, consumer, decomposer, trophic level, food chain, food web, niche, habitat, community, ecosystem, biome, biosphere, biomass;
b) distinguish between biotic and abiotic environmental factors (2b);
c) categorize common organisms as herbivore, carnivore, omnivore, or decomposer (2b, 2g, 8e);
d) construct food chains from lists of common organisms (2a, 2g, 2h);
e) distinguish between the niche and habitat of an organism (2a, 2h, 2i);
f) explain community structure in terms of trophic levels (2a, 2g, 2h);
g) recognize the relationship between number of predators and number of prey (2a, 2g, 2h);
h) identify the factors affecting population growth (2a, 2d-2h);
i) distinguish among ecosystems, biomes, and the biosphere (2a, 2i);
j) recognize the major biomes in Canada and their basic characteristics (2i);
k) explain the meaning and importance of *natural succession* (2a, 8b, 8c);
l) compare the flow of one material through an ecosystem with the flow of energy through the same ecosystem, for example, the carbon or water cycle (2a, 2i, 8b, 8c);
m) recognize the human as a manipulator in Canadian biological communities (2a, 2i, 3, 4);
n) explain the importance of maintaining a balance in the environment (2a-2e, 2h, 4).

2. Student Activities

It is highly recommended that a field trip and another outdoor investigation be included in the activities if at all possible. Students are to:

a) help plan and participate in a field trip to a natural community in order to study biotic and abiotic factors, including, for example, the identification of organisms, niches, and populations (5a, 6, 8b, 8c);
*b) set up a classroom ecosystem in a terrarium or bottle;
c) create a freshwater community in an aquarium using pond water and mud and microscopically study and explain changes in the community over a period of time;
*d) perform an experiment to observe population growth in, for example, yeast and fruit flies (5b);
e) perform an experiment to show the effect of overcrowding on seeds. For example, they could grow radishes or lettuce in peat pots;
f) do an outdoor population sampling and an estimation of the biomass of a common plant (e.g., of the dandelion or plantain, using a quadrat sampler and transect line);
g) do a simulation of the prey-predator relationship (8e);
h) analyse a population case study, for example, of deer, porcupines, or humans (4e, 5b, 5c);
i) do a library-search report on the major inhabitants, environmental conditions, interrelationships, and human activities in one of the major Canadian biomes, such as the tundra, grassland, or coniferous forest (3c, 4a, 4e, 5c).

3. Applications

a) A knowledge of ecology will enable students to develop informed opinions on environmental issues.
b) Information on natural relationships could help property owners to learn how to manage their property through composting, landscaping, and special plantings to attract wildlife and control climate.

4. Societal Implications

a) Increasing demands for energy and minerals always have environmental implications. To make the wisest possible decisions, the Canadian public must be well informed.
b) Many species of plants and animals are threatened by human initiatives that result in environmental change.
c) Environmental issues (e.g., whaling, seal hunting, nuclear power stations) often become highly publicized and emotional, and objectivity may be lost.
d) Much human employment and recreational activity depends on natural resources (e.g., fishing, logging), making the intelligent management of these resources necessary.
e) Interest in natural interrelationships may encourage students to take more responsibility for their own environment.
f) This unit will help familiarize students with a variety of careers that involve outdoor studies (e.g., forestry, wildlife management, conservation, land management).

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) laboratory work and reports, including the field trip if taken;
b) graphing and analysis of population data;
c) a population case study or a library-search report.

6. Safety Considerations

Safety procedures should be established prior to a field trip. Checks for allergies or health problems should be conducted before the trip. Appropriate first-aid supplies should be carried.

7. Possible Extensions

Some students might:

a) plan a study of a natural community near the school and be responsible for collecting and analysing their data and reporting to the class;
b) compare populations and environmental conditions in a natural community with those in an urban community;
c) observe and record evidence of secondary succession in areas near their home or school;
d) brainstorm and discuss the possible environmental effects of a single human project (e.g., a road, an apartment building, a power station, a dam, a water reservoir, a strip mine, an airport);
e) conduct a long-term ecological study by making and recording observations of environmental changes in one community and accounting for these changes.

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* See the subsection entitled "Student Activities" on page 6.

8. Some Teaching Suggestions

a) An "ecology centre" could be maintained on a bulletin board. Students could display clippings from newspapers and magazines about pollution or other environmental problems. Such a centre could provide topics for discussion and debate and add relevance to the unit.
b) This unit should be organized around one major or several short field trips. Field trips provide students with the best opportunity to design, perform, and report on scientific activities in the natural environment and make their study more meaningful.
c) Ecological data should be collected from places familiar to students. It should be emphasized that all communities, from a parking lot to the arctic tundra, contain interesting ecological relationships.
d) Excellent audio-visual aids are available for ecological studies and can be used in this unit.
e) A prey-predator simulation, as in activity 2g, can be created through the use of cutout pictures or names of organisms in proportion to their actual numbers in a food chain. These could be manipulated to demonstrate the effects of predation on the numbers in the lower levels of the food chain.

Core Unit 2

Organisms and Their External Environment

Time: 16 hours

The external environment (the outside world) of an organism can be friendly and life-sustaining or cold and hostile. Organisms depend on their environment for nutrients and respiratory gases. They must constantly monitor their surroundings and respond to any threatening changes. This unit will focus on protists and animals, their exchange of material with the environment, and the adaptations in their sensory and locomotory systems that help them survive.

This unit may be divided into topics such as the following:

- The variety of organisms and environments
- Sensing environmental change
- Locomotory systems
- Food from the environment
- Altering the environment
- Adapting to the environment

1. Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation of the needs of all organisms (3a);
b) an appreciation of the environment as a supplier of materials for living things (3a);
c) a respect for the variety, complexity, and sanctity of living things (3b, 4c, 8e);
d) a sense of responsibility for preserving life and a life-sustaining environment (3a).

Skills. Students will have the opportunity to develop skill in:

a) classifying a variety of organisms (8a);
b) observing living organisms under a microscope (2a, 2b);
c) imposing changes on living organisms in a laboratory investigation and relating the results to other organisms in their natural environment (2b, 2c);
d) reaching conclusions about the effects of different environmental changes on protozoa (2b);
e) handling living and preserved specimens (2a, 2e);
f) recording information about organisms and their environment (2b, 8b);
g) using the resource centre to collect information for a report (2h).

Knowledge. Students will be expected to:

a) describe the five-kingdom method of classifying organisms and give examples of organisms in each kingdom (8a);
b) identify the range of environmental conditions in which organisms may survive;
c) list the environmental conditions with which an organism must cope (e.g., temperature, light, enemies, food sources, terrain, wind);
d) explain the role of the sensory organs in monitoring environmental changes (2d, 2e);
e) describe the sensory organs of the grasshopper, earthworm, and perch (2e);
f) describe locomotion in the paramecium, grasshopper, earthworm, and perch (2e);
g) describe how the paramecium, grasshopper, and earthworm gather food from their environment (2e);
h) compare the composition of air before and after gas exchange (2f);
i) describe how the process of excretion in animals affects the environment;
j) identify and explain several mechanisms used by organisms to survive harsh environmental conditions, for example, migration, hibernation, camouflage, and social structure (2h).

2. Student Activities

Students are to:

*a) perform an experiment to observe the method of locomotion of one or more common protozoa (8b);
*b) perform an experiment to observe the effect of environmental changes on protozoa (8b);
*c) perform an experiment to study the effect of temperature and light on the behaviour of an animal (e.g., mealworms);
d) perform experiments to test their own senses of hearing, seeing, smelling, and tasting (6c, 8c);
*e) examine the external structures of a grasshopper and a perch to observe the locomotory and sensory systems (6a, 6b, 8e);
f) perform an experiment to show that respiration releases carbon dioxide into the air;
g) perform an experiment to test the human response time to an environmental change;
*h) use the library resource centre to investigate and write a report on (i) the migration of one species of Canadian waterfowl or the hibernation of one species of Canadian mammal or (ii) a social insect and the particular benefits that its social structure contributes to the survival of the species (5b, 8e, 8f).

3. Applications

a) The survival of the human race and other living things depends on a suitable environment that contains food, water, and oxygen.
b) The earthworm and grasshopper are economically important to humans because of their own roles within the environment.
c) Humans have created much technology and spend a great deal of money on systems for monitoring the environment and informing people of the result (e.g., weather forecasting).
d) The migratory nature of some species provides us with the opportunity to harvest, individually or commercially, animals such as salmon, trout, ducks, and geese.

4. Societal Implications

a) Human activities have the greatest potential for bringing about massive environmental change.
b) People use their inventive nature to create technology that permits human life in extreme environmental conditions. We can exist in airless space by taking our own supporting environment with us. Using this method, people may colonize hostile planets for long periods of time.
c) Unlike humans, simpler organisms are not always able to create friendly environments for themselves. Nevertheless, bacteria can live in the harshest climates on earth, and insects still thrive after many periods of widespread climatic change. Important questions have been raised concerning which species will best survive future environmental change.
d) Instruments developed by human technology to extend the senses include telescopes, radio receivers, microscopes, binoculars, satellites, satellite dishes, computers, and spectrometers. Each device helps us increase our knowledge of the environment.

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* See the subsection entitled "Student Activities" on page 6.

e) People can easily obtain a change in their environment by moving to a new one. Our technology to improve human mobility includes trains, automobiles, airplanes, ships, and a wide variety of other land, sea, and air vehicles.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) laboratory work and related reports;
b) written reports prepared in activity 2h.

6. Safety Considerations

a) Students should wash their hands after handling preserved earthworms or perch.
b) Preservatives from animal specimens should be rinsed off before activity 2e to minimize student contact with these chemicals.
c) Appropriate precautions should be taken in smelling and tasting in activity 2d.

7. Possible Extensions

Some students might:

a) study the specific structural adaptations of various animals (e.g., birds for flight, fish for swimming, whales for living in the sea, arctic hare for surviving a harsh northern climate);
b) extend the laboratory examination of structural adaptations for gas exchange, locomotion, and food gathering to other species (e.g., crayfish, frogs);
c) maintain a culture of daphnia, hydra, or planaria, observe their locomotory and gas-exchange systems, and carry out experiments to test the response of these invertebrates to heat, light, chemicals, and food;
d) study structural variation within one species (e.g., Darwin's finches);
e) brainstorm and list some methods of environmental control used in a home, school, or spacecraft;
f) study the characteristics of one particular harsh environment (e.g., the Canadian Arctic), along with the survival techniques and structural adaptations of many common species within that environment.

8. Some Teaching Suggestions

a) The five-kingdom method of classification should serve as the basis for identifying the organisms examined in this unit and in core unit 3. A detailed study of the methods of classification should not be required, but an introduction to the main classification levels – kingdom to species – is useful. A look at sample species within the Monera, Protista, and Animalia kingdoms, as well as the representative environments that they inhabit, can be a good way to start the unit.
b) A drop of glycerin on the slide with living protozoa can be used to slow down the organism for microscopic study in activity 2a. Because the glycerin alters the environment of the protozoa, students can also make observations here as a part of activity 2b. Small amounts of sugar, salt, and vinegar could be added to separate cultures of protozoa while under microscopic observation to complete activity 2b.
c) Experiments to test human senses can focus on the localization of, and responsiveness to, touch; the ability to distinguish differences in temperature; visual acuity at various levels of light intensity; the taste response of the tongue; and the efficiency of the sense of smell.
d) A detailed study of the external anatomy of the organisms in this unit should not be attempted. The emphasis should be placed on adaptations that help each organism become aware of its environment, exchange materials with it, and survive environmental changes.
e) The reasons for the widespread success of insects should be discussed in this unit. Such a discussion should follow the examination of the structure of an insect and could include some reference to the ability of insects to adapt to natural environmental changes, insecticides, and different food sources.
f) Alternate protists, invertebrates, and vertebrates can be chosen for study throughout this unit, but insects should be included as representative of invertebrates because of their successful survival and widespread distribution in the ecosystems of the world.

Core Unit 3

Organisms and Their Internal Environment

Time: 16 hours

An animal is an intricate but organized collection of cells and tissues. Each cell requires a share of the oxygen and nutrients consumed by the animal, and each produces waste. Organs and organ systems exist within multicellular species to ensure the even distribution of materials and the removal of waste. Even unicellular protozoa have organelles to create a suitable internal environment. In this unit students will study some of the organelles, organs, and organ systems that maintain the internal environment of protists and animals.

This unit may be divided into topics such as the following:

- Gas-exchange systems
- Digestive systems
- Circulatory systems

1. Objectives

Attitudes. Students will be encouraged to develop:

a) a respect for the complexity and uniqueness of living things (2b, 2c, 3a);
b) an appreciation of dissection as an excellent technique for acquiring knowledge about living things, but one that should be used sparingly (2b, 2c, 3b, 4b, 8e);
c) a commitment to precise and careful dissection techniques (2b, 2c, 2e);
d) an appreciation of the similarity in both the needs and the methods of meeting such needs in all organisms (2a-2c, 3a).

Skills. Students will have the opportunity to develop skill in:

a) following proper procedures during a dissection (2b, 2c);
b) manipulating dissecting instruments (2b, 2c);
c) observing details during dissections (2b, 2c, 2e);
d) handling preserved specimens (2b, 2c);
e) recording information about the gas-exchange, digestive, and circulatory systems (2b, 2c);
f) drawing diagrams of specific organ systems (2b, 2c, 2e);
g) comparing gas exchange, digestion, and circulation in a representative protozoan, invertebrate, and vertebrate (2a-2c);
h) applying the knowledge obtained from dissection to a variety of organisms (3a, 3b, 4b).

Knowledge. Students will be expected to:

a) list the functions of a gas-exchange system (2b, 2c);
b) describe the method of gas exchange in a representative protozoan, such as a paramecium or an amoeba (2a);
c) describe the structures in the gas-exchange system of a representative invertebrate and vertebrate, such as the earthworm and the perch (2b, 2c);
d) explain how gas exchange occurs in the representative animals (2b, 2c);
e) trace the pathway of air from the external to the internal environment of the representative animals (2b, 2c);
f) list the functions of a digestive system (2b, 2c);
g) describe how the representative protozoan digests food (2a);
h) describe the structures in the digestive system of the representative invertebrate and vertebrate (2b, 2c);
i) explain how digestion occurs in the representative animals (2b, 2c);
j) trace the pathway of food from ingestion to removal of indigestible waste within the representative animals (2b, 2c);
k) list the functions of a circulatory system (2b, 2c);
l) describe how fluids are circulated in the representative protozoan (2a);
m) describe the structures in the circulatory system of the representative invertebrate and vertebrate (2b, 2c);
n) explain how circulation occurs in the representative animals (2b, 2c);
o) trace the pathway of circulatory fluids within the representative animals (2b, 2c).

2. Student Activities

Students are to:

- *a) use a microscope to observe the internal structure of a protozoan and then sketch the internal structure (5a);
- *b) dissect an earthworm, focusing their attention on the gas-exchange, digestive, and circulatory systems (5b, 5c, 6a, 6b, 8b, 8d, 8e);
- *c) dissect or observe a demonstration of the dissection of a perch, focusing their attention on the gas-exchange, digestive, and circulatory systems (5b, 5c, 6a, 6b, 8b, 8d, 8e);
- d) perform experiments to test the effect on human pulse rate, breathing rate, and body temperature of brief periods of exertion (6c, 8a, 8f);
- e) observe a demonstration of the dissection of a mammalian heart or lung (8c, 8e).

3. Applications

a) An understanding of the systems of representative animals could lead to a better understanding of animal systems in general.

b) The patience and manipulative skills required for careful and systematic dissection are useful for developing small-motor and investigative skills in students.

4. Societal Implications

a) Animal systems such as digestive and circulatory systems can usually successfully process a variety of different substances. However, if substances are introduced that the systems cannot properly process, the entire organism suffers. For this reason, care must be taken to limit the intake of toxic substances (e.g., benzene, carbon tetrachloride).

b) A knowledge of internal organs and the ability to operate on them is essential to surgeons, doctors, veterinarians, and others in the medical field. Surgery plays an important role in the maintenance of life.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

- a) laboratory work and reports and sketches resulting from microscopy observations;
- b) dissection techniques;
- c) identification of the components of the gas-exchange, digestive, and circulatory systems in the specimens dissected in activities 2b and 2c.

6. Safety Considerations

a) Students should wear protective eyewear, gloves, and aprons during all dissections.

b) Students should wash their hands after contact with specimens and should clean up dissection equipment and the laboratory work space after dissecting.

c) Students with respiratory disorders or heart problems should not be asked to take an active part in any experiment involving exercise or exertion. They can participate in gathering the experimental data.

7. Possible Extensions

Some students might:

- a) study the gas-exchange, digestive, and circulatory systems of additional animals (e.g., crayfish, frogs);
- b) study excretory systems in the representative animals;
- c) determine the volume of air exhaled during regular breathing and the maximum volume of air that can be exhaled after a deep breath;
- d) discuss the composition of blood and lymph and how they help maintain an internal balance within the body.

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* See the subsection entitled "Student Activities" on page 6.

8. Teaching Suggestions

a) The objectives and activities in this unit should not focus on human systems. Senior Division biology courses cover many of the human organ systems and related physiology. Teachers should minimize their coverage of human systems in this unit in order to avoid unnecessary overlap with Senior Division courses.

b) The role of the gas-exchange, digestive, and circulatory systems in maintaining the internal environment of an organism should be emphasized. This, along with an emphasis on the similarities in the roles and structures of the various systems, should ensure that this unit will complement core unit 2, "Organisms and Their External Environment".

c) Sheep or beef hearts and lungs are often available fresh from butcher shops and can be used for demonstrations.

d) Alternative representative animals can be used in activities 2b and 2c.

e) In this unit the teacher should emphasize the need to respect living things. Although dissections are a part of the course, it should be pointed out that such dissections, particularly of vertebrates, are kept to a minimum and that organs such as the mammalian hearts and lungs used in dissections are taken from animals that are used for other purposes. The teacher should be familiar with the policy stated in subsection 9.3, "Animal Care in Science Courses", in Part 1 of this curriculum guideline.

Core Unit 4

Heat

Time: 16 hours

Heat is a form of energy that has great significance in our everyday lives. It is important that students understand its properties and how it is measured. In this unit students will perform experiments to learn facts, concepts, and physical principles related to heat. The kinetic molecular theory is introduced and is used to explain the concepts of heat energy, temperature, heat transfer, change of state, and thermal expansion. Quantity of heat, specific heat capacity, latent heat, and the principle of heat transfer are studied quantitatively.

This unit may be divided into topics such as the following:

- The kinetic molecular theory
- Thermal expansion
- Heat transfer by convection, conduction, and radiation
- Quantity of heat
- Heat transfer by mixing
- Latent heat of fusion and vaporization
- The law of conservation of energy

1. Objectives

Attitudes. Students will be encouraged to develop:

a) a concern about the wise use of heat energy (3d, 4c);

b) an appreciation of the various roles that heat plays in our lives (3a-3f).

Skills. Students will have the opportunity to develop skill in:

a) observing the expansion of a solid, a liquid, and a gas as a result of heat (2a, 8a);
b) inferring that heat causes expansion of matter in each of the three states (2a, 8b);
c) distinguishing between observations and inferences (2a);
d) manipulating and reading a thermometer (calibrated in degrees Celsius) to measure temperatures (2d-2f);
e) plotting a heating curve of temperature against time (2d);
f) analysing the results of an investigation and making a generalization (2d-2f);
g) calculating the quantity of heat using the formulas $Q = mc\triangle t$, $Q = ml_f$, and $Q = ml_v$;
h) formulating a hypothesis about the final temperature when two samples of water at different temperatures are about to be mixed (2f, 8e);
i) calculating and comparing the heat lost by a sample of hot water and the heat gained by a sample of cold water on mixing the two samples (2f);
j) solving problems in SI units involving quantity of heat and heat transfer when substances are mixed (5c).

Knowledge. Students will be expected to:

a) describe and compare the thermal expansion of solids, liquids, and gases (2a, 8a);
b) describe and explain the meaning of *conduction*, *convection*, and *radiation* (2b, 8a);
c) state the main postulates of the kinetic theory of matter (8b);
d) use the kinetic theory to explain thermal expansion and heat conduction (8b);
e) explain the significance of the fixed points of the Celsius scale (2c, 2d);
f) describe how a substance can be heated without undergoing a temperature change and also explain what occurs when its temperature does rise (2d);
g) define or correctly use the following terms: temperature, heat energy, thermal energy, heat capacity, specific heat capacity, latent heat, specific latent heat of fusion and of vaporization;
h) list the three factors that affect the quantity of heat energy gained or lost by a substance and state how each factor affects that quantity (2e);
i) explain the variability in the specific heat capacity of different substances in terms of the kinetic theory and indicate the significance of high and low heat capacities in different substances (8b);
j) explain some effects that are a result of latent heat (e.g., the severity of a burn caused by steam compared to one caused by hot water);
k) state the law of conservation of energy and indicate how it applies when two substances are mixed (2f);
l) state the quantity of heat in SI units required to (i) raise the temperature of 1 kg of water by 1 °C, (ii) melt 1 kg of ice at 0 °C, and (iii) change 1 kg of water to steam at 100 °C.

2. Student Activities

Students are to:

a) observe demonstrations of the effect of temperature change on the volume of a solid, a liquid, and a gas (6, 8a, 8b);
b) observe demonstrations of the transfer of heat by conduction, convection, and radiation (6, 8a, 8b);
c) determine the fixed points on an uncalibrated thermometer (6);
*d) heat some ice and the resulting water until the water has boiled for a few minutes and graph the temperature against the time taken (5b, 6, 8c);
*e) verify that the amount of heat energy transferred to a substance varies with (i) the temperature change in the substance, (ii) its mass, and (iii) the kind of substance (6);
*f) mix two samples of water having different masses at different temperatures; record the initial temperatures of the samples and the final temperature of the mixture; and calculate and compare the heat lost by the hot water and the heat gained by the cold water (6, 8e).

3. Applications

a) The operation of thermometers and thermostats is based on the principle of thermal expansion.
b) The air pressure in tires varies with temperature and has to be checked regularly.
c) Weather phenomena are partially explained by the absorption of solar radiation and the effects of convection currents.
d) Insulation and thermopane windows are applications of the principles of heat transfer.
e) The specific heat capacities and latent heats of different liquids are important factors in determining the choice of coolants for refrigeration systems.
f) Cooling systems such as fins on motorcycle engines, the piping on the back of a refrigerator or air conditioner, and the baffles on car radiators are applications of the principles of radiation and convection of heat energy from a surface.

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[*] See the subsection entitled "Student Activities" on page 6.

4. Societal Implications

a) Imaginative heating and cooling systems have improved the quality of our lives.
b) Nuclear fuels are used to produce electrical energy, which in turn is used to keep us warm in the winter and cool in the summer. This source of energy, however, presents possible hazards, which must be controlled.
c) The wise use of heat energy is important because supplies of conventional fossil fuels are declining.
d) Waste heat from industries and electrical generating stations is sometimes released in the form of hot water and can cause environmental damage. However, this waste heat can also be used to society's advantage.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) written laboratory reports;
b) plotting and analysis of a heating curve on a graph;
c) mathematical solving of heat problems.

6. Some Safety Considerations

a) Protective eyewear should be worn and loose hair should be tied back when substances are being heated.
b) Appropriate precautions should be taken to avoid burns during the handling of hot liquids and containers.
c) Any immersion heaters that are used must be approved and in excellent condition.

7. Possible Extensions

Some students might:

a) measure the heating values (energy content) of various foods;
b) determine the quantity of heat energy required to raise the temperature of 1 kg of water by 1°C;
c) determine the specific heat capacity of a metal and a liquid (8d);
d) determine the heat of fusion of ice (8d);
e) determine the heat of vaporization of water (8d);
f) test the insulating and conducting properties of several substances;
g) investigate heat pumps, solar heaters, heat exchangers, plenum heaters, geothermal heating, or ocean thermal gradients;
h) investigate the function of hot packs, cold camper packs, athletic packs, or thermos bottles.

8. Some Teaching Suggestions

a) Some students who have had optional unit 2, "Heat and Temperature", in Science, Grade 8, will have studied expansion, conduction, and radiation. Such students can be chosen to conduct demonstrations, and the teacher can then introduce new examples to illustrate expansion and heat transfer.
b) Activities 2a and 2b should provide an opportunity for students to use the kinetic theory of matter to explain their observations. The postulates of the particle theory should be reviewed. The historical development of the kinetic theory of matter should be included to reinforce students' understanding of the nature and role of theories in science. The concepts of heat energy, thermal energy, and temperature as they relate to the motion of particles and the kinetic theory should be taught. The anomalous behaviour of water when heated from 0°C to 4°C should be discussed as an apparent contradiction to the kinetic theory of matter.
c) In activity 2d, a small amount of ice should be used in order to save time. Readings of the temperature can be taken every half-minute.
d) Quantitative determinations of the specific heat capacity, latent heat of fusion, or latent heat of vaporization of a substance are not required in Grade 10. Such activities are reserved for Senior Division courses but may be performed under "Possible Extensions" in this unit by some students, if desired.
e) Activity 2f can begin with students' attempting to formulate a hypothesis and guessing the final temperature before mixing the samples. This will be more challenging if the initial masses and temperatures are not measured in round numbers. This activity should be used to illustrate the law of conservation of energy.
f) It should be noted that the calorie is not permitted for use with the SI. However, some mention of the calorie and kilocalorie might be made, since they are still in use in certain sectors such as dietetics, where the conversion to kilojoules is underway but gradual.
g) Since the joule is equivalent to a watt second, an immersion heater can be used to determine the quantity of heat energy delivered to a liquid in a given time. Provided that safety precautions are taken, immersion heaters may be used, particularly for some of the activities listed under "Possible Extensions". Since the equivalence of the joule and watt second will not have been introduced in previous courses, students will have to accept the relationship prior to a formal definition of the watt.

Core Unit 5

Applied Chemistry

Time: 16 hours

The applications of chemistry are numerous in everyday life. The majority of substances that we use today are synthetic and have been developed through chemical and engineering technology. This unit introduces students to a wide variety of chemical applications in a practical laboratory setting. However, the factual content and the chemistry of these applications are not the central focus of the unit. The key issue is to make students aware of the importance of chemistry in everyday life.

This unit may be divided into topics such as the following:

- ▶ Fractional distillation of crude oil
- ▶ Consumer products
- ▶ Acids and bases
- ▶ Dyes and dyeing
- ▶ Hard and soft water

1. Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation of the role of chemistry and chemicals in their lives (3, 4);
b) a respect for safety precautions and the need to observe directions on containers of chemicals and consumer products (4c).

Skills. Students will have the opportunity to develop skill in:

a) distilling a sample of crude oil and collecting four fractions or following procedures to prepare a consumer product (2a);
b) estimating the pH of common materials, using universal indicator paper (2c);
c) classifying common materials as acidic, basic, or neutral on the basis of their pH values (2c);
d) dyeing fabrics and testing the fastness of dyed fabrics (2e);
e) observing the effect of using a mordant in dyeing fabrics (2e);
f) observing the reactions of hard and soft water with soap (2f);
g) softening a sample of hard water, using washing soda (2f);
h) controlling variables in experiments on soft and hard water (2f).

Knowledge. Students will be expected to:

a) describe the fractional distillation of crude oil or describe how to prepare a consumer product such as soap (2a);
b) state some characteristics of acids and bases, such as taste, action on indicators, and corrosive effect (2b, 2c, 6a);
c) define the pH of a substance as a number that expresses its acidity or basicity (8c);
d) use the pH scale and the pH value of a substance to classify it as acidic, basic, or neutral (8c);
e) list some common materials and foods that are acidic and some that are basic (2c, 8d);
f) give examples of synthetic and natural dyes and describe how a fabric is dyed with each type (2e);
g) define *mordant* and give an example of a mordant (2e);
h) explain how a mordant helps to fix a dye to a fabric (2e);
i) compare the reaction of soft and hard water with soap (2f);
j) explain the causes of hardness in hard water and describe how to soften a sample of hard water (8f, 8i).

2. Student Activities

Students are to:

*a) (i) perform or observe a demonstration of an experiment to distil and collect four fractions of a small sample of crude oil *or* (ii) prepare a consumer product such as soap, nylon, or detergent (5, 6c, 6f, 8a, 8b, 8g);
b) extract coloured substances from plants and observe the colour changes that occur when the extract is added to acidic and basic solutions (6d, 8c);
*c) find the pH of common materials, using universal indicator paper (6d, 8d);
d) compare the effectiveness of several antacids in neutralizing an acid solution (8e);
*e) (i) dye various fabrics with natural and synthetic dyes and test the fastness of the dyes; (ii) use a mordant to help a dye stick to fabrics (6e);
*f) compare the reaction of soft and hard water with soap and soften a sample of hard water, using washing soda (sodium carbonate) (8f, 8h).

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* See the subsection entitled "Student Activities" on page 6.

3. Applications

a) The raw materials for thousands of products used in daily life come from crude oil.
b) Nylon and other synthetic fabrics are used to manufacture inexpensive, durable, colourful, attractive, and easy-care fabrics.
c) Oven cleaners, drain-pipe cleaners, and window cleaners contain chemicals that dissolve grease and are usually very basic.
d) Strongly basic solutions destroy protein structures. Thus, shampoo and conditioners for treating hair, as well as fabric cleaners for cleaning silk and wool garments, are mildly acidic.

4. Societal Implications

a) In most instances the applications of chemistry are advantageous, as in the production of consumer products and synthetic materials. In some instances the applications may have direct or indirect negative consequences, as in the use of some pesticides and the disposal of by-products that are harmful to the environment.
b) The manufacturing, distribution, promotion, and marketing of chemistry-related consumer products provide jobs for many thousands of people.
c) The advertising and packaging of a consumer product plays an important role in marketing the product. It is appropriate for the consumer to investigate critically the composition of the product.
d) Synthetic fibres and fabrics generally reduce the cost and improve the appearance of our clothes.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students' laboratory work and written reports. In this unit special emphasis should be placed on the evaluation of students' ability during laboratory activities.

6. Safety Considerations

a) Chemicals should be kept away from the mouth and clothing. Students should wash their hands after handling chemicals.
b) Protective eyewear should be worn and loose hair should be tied back when substances are being heated.
c) Students should not use or take home the soap and the synthetic detergent prepared in class.
d) Appropriate precautions should be taken in handling corrosive acids and bases.
e) Dyes will stain skin as well as clothing and should be handled with care.
f) In activity 2a, a small amount of crude oil (2 mL) should be used. The sample should not be heated beyond 230 °C in the distillation process. Heat-resistant glasswear should be used.

7. Possible Extensions

Some students might:

a) investigate and explain the action of baking soda and baking powder in baking;
b) study the chemistry of various cleaners;
c) prepare a window cleaner or furniture polish;
d) investigate the action of fabric softeners;
e) study the chromatography of dyes;
f) investigate and explain what happens when eggs are cooked or beaten.

8. Some Teaching Suggestions

a) The fractional distillation of crude oil can be done in a side-arm test tube. The crude oil should be distilled slowly, and the first fraction collected in a test tube cooled in a beaker of water. Students can collect four fractions with roughly the following boiling ranges: (i) room temperature to 70 °C, (ii) 70-120 °C, (iii) 120-170 °C, (iv) 170-220 °C. Students can examine the four fractions for viscosity, colour, and flammability (pouring each fraction in turn into a crucible and lighting it with a burning wood splint). Fume hoods should be used, or the room should be well ventilated.
b) Students can prepare nylon, taking the usual precautions in handling chemicals. Nylon is produced in the reaction of adipyl chloride solution in hexane (0.25 mol/L) and hexamethylene diamine solution in sodium hydroxide (dissolve 14 g of $NaOH_{(s)}$ into 1 L of distilled water and add 26 g of hexamethylene diamine). Five millilitres of each solution should be sufficient. The teacher should prepare the solutions in advance.
c) Red cabbage, beetroot, tea, and blueberries can be used as indicators. The result of activity 2b should lead to the introduction of the universal indicator and other common indicators. The pH scale should be discussed as a scale of numbers used to indicate the acidity and basicity of solutions. The quantitative definition that determines this scale is not required in this course.
d) In activity 2c, the universal indicator paper can be used to find the pH of such common materials as toothpaste, lemon juice, tap water, salt solution, baking soda, washing soda, vinegar, acetylsalicylic acid, detergents, soap, indigestion powder, shampoo, and various foods.

e) In activity 2d, any commercial antacid in tablet, liquid, or powdered form can be used. A 1 g sample of the antacid should be titrated with hydrochloric acid of concentration 1.0 mol/L, with a suitable indicator being used. If an eyedropper is used for the titration, it should first be calibrated to determine the number of drops that make a millilitre of water.
f) Activity 2f should provide students with an opportunity to control variables. The precipitation reactions involved in the softening of hard water can be discussed, and word equations can be used to describe these reactions.
g) Lard can be used in the preparation of soap. It works well and is inexpensive. Although alcohol is not used in commercial soap making, ethyl alcohol can be used in laboratory soap making to bring the reacting materials into more intimate contact and thus speed up the reaction.
h) Students can practise formulating a hypothesis in activity 2f.
i) Students were introduced to a few chemical symbols of elements in core unit 2, "Chemical Change", in Science, Grade 9, Advanced Level. It would be appropriate to review and extend students' knowledge of chemical symbols for any new elements encountered in this unit.

Core Unit 6

Magnetism and Electricity

Time: 16 hours

Devices based on the principles of magnetism and electricity are so much a part of modern living that it is difficult to conceive of our world without them. This unit is intended to help students understand some of the essentials related to magnetism and electricity. Investigations in the unit will help students to learn the laws of magnetism and electrostatic charges, as well as study some features and properties of magnetic force fields, electrostatics, and electric circuits.

This unit may be divided into topics such as the following:

- Magnetism
- Electrostatics
- Electric current
- Electric circuits

1. Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation of the many devices that are powered by electricity and their contribution to our way of life (3b-3e, 4a);
b) curiosity about the relationship between magnetism and electricity (2g, 2h, 8a, 8h).

Skills. Students will have the opportunity to develop skill in:

a) manipulating a spring scale to measure magnetic forces (2b, 8c);
b) plotting and drawing a two-dimensional diagram of the magnetic force field around a bar magnet (2c);
c) charging an electroscope by contact and by induction (2d, 8d);

d) constructing a simple voltaic cell and detecting an electric current produced by the cell (2e, 8e);
e) constructing series and parallel circuits (2f, 8f, 8g);
f) drawing circuit diagrams of simple series and parallel circuits (2f, 8g);
g) constructing an electromagnet (2g, 8h);
h) inferring the existence of a magnetic force field around a wire carrying an electric current (2g, 8h);
i) inducing an electric current in a conductor by moving it through a magnetic field (2h, 8h).

Knowledge. Students will be expected to:

a) describe how to measure a magnetic force (2b, 8c);
b) define *magnetic force field* as "the region in space in which a magnetic force can be detected" and describe how to determine the pattern of the field around a bar magnet (2c, 8b, 8i);
c) describe how to charge an electroscope by contact and by induction (2d, 8d);
d) explain charging by contact and by induction in terms of the electron theory (2d, 8d);
e) name the parts of a voltaic cell and describe the conditions necessary for producing a steady supply of electrons (2e, 8e);
f) state the basic characteristics of series and parallel circuits, indicating how the current flows (2f, 8f, 8g);
g) describe the structure of an electromagnet (2g);
h) state the magnetic effect of an electric current (2g, 8h);
i) describe how to generate an electric current in a conductor by moving it across a magnetic field (2h, 8h).

2. Student Activities

Students are to:

a) investigate the interaction of a bar magnet with different materials (magnetic and non-magnetic), a compass, and another magnet and use the data to infer the law of magnetic attraction and repulsion (8b, 8c);
*b) measure magnetic forces, using a spring scale (8c);
*c) determine, by means of iron filings or small compasses, the pattern of a magnetic force field about a bar magnet (8a, 8b, 8i);
*d) charge an electroscope by contact and by induction and explain the process in terms of the electron theory (8d);
*e) make a simple voltaic cell and use a light bulb or a galvanometer to detect the electric current produced by the cell (6b, 8e);
*f) construct series and parallel circuits, compare the intensity of the electric current in the different parts of the circuits, and deduce the basic characteristics of both types of circuits (5a, 5c, 6a, 6c, 8f, 8g);
*g) construct an electromagnet and infer the existence of a magnetic force field around a wire that conducts an electric current (8h);
*h) produce an electric current by moving a conductor across a magnetic field (8h).

3. Applications

a) Compasses are useful because they are sensitive to the magnetic force field of the earth.
b) Electric razors, doorbells, stereo speakers, ovens, toasters, light bulbs, televisions, radios, vacuum cleaners, clothes washers and dryers, dishwashers, computers, electric heaters, refrigerators, hair dryers, fans, elevators, and escalators all require electricity.
c) Information is stored on audio and computer tapes by magnetic means.
d) Some electric cranes make use of electromagnets.
e) The separation of ferrous and non-ferrous materials is often based on the magnetic attraction of ferrous materials.
f) Industrial and home wiring makes use of the principles of series and parallel circuits.

4. Societal Implications

a) Electricity has provided for a change in our lifestyle by reducing workloads and increasing leisure time.
b) The production and distribution of electricity and electrical devices is a major source of employment.
c) The by-products of electricity-generating stations produce acid rain where fossil fuels are burned, radioactive wastes where nuclear energy is applied, and thermal pollution where steam generation is utilized.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) laboratory work, including the construction of series and parallel circuits;
b) written laboratory reports;
c) circuit diagrams (8g).

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* See the subsection entitled "Student Activities" on page 6.

6. Safety Considerations

a) Students should use only low voltages and low currents during experiments involving electricity.
b) Appropriate precautions should be taken in using corrosive chemicals for the construction of an electrochemical cell.
c) Only electrical devices that have been approved (e.g., by the CSA or Ontario Hydro) should be used.

7. Possible Extensions

Some students might:

a) investigate the manufacture of permanent magnets;
b) determine the direction of the lines of force around a straight wire carrying an electric current;
c) design investigations to show some energy transformations involving electric or magnetic energy;
d) visit a power-generating station;
e) examine the structure of dry and wet cells or batteries;
f) use the library resource centre and other community resources to study and prepare a report on the structure and function of a device that uses the principles of magnetism and electricity.

8. Some Teaching Suggestions

a) Throughout the unit the dependence of society on electricity and magnetism and the fact that each can be generated from the other should be stressed.
b) At the beginning of this unit students' knowledge about magnetism should be assessed. Students may already be familiar with magnets and related terms and properties. Undesirable repetition should be avoided. The results of activity 2a should be used to introduce briefly or review the law of attraction and repulsion, magnetic and non-magnetic substances, how a magnet may be made, and the molecular theory of magnetism.
c) In activity 2a, students should be able to feel or observe the forces exerted by magnets. In activity 2b, students can measure magnetic forces by attaching a spring scale to a magnet. The meaning of the term *force* and the SI unit of force, the newton, as taught in Grade 8, should be reviewed.
d) The production of positive and negative electrostatic charges by friction and the law governing the attraction and repulsion of unlike and like charges is presented in core unit 2 of the Grade 9 course. The study of electrostatics in this unit should be a continuation of that work. The results of activity 2d should be explained in terms of the electron theory.
e) Activity 2e should provide an opportunity for students to observe the evidence that indicates a continuous flow of electrons (electric current) in a closed circuit. A simple explanation of the chemical action that provides a steady supply of electrons in the voltaic cell should be given.
f) In activity 2f, students can use the brightness of light bulbs to compare the intensity of the electric currents in the different parts of simple series and parallel circuits. The emphasis in this activity should be placed on developing students' understanding of the meaning and characteristics of series and parallel circuits. Ammeters can be used to measure the total current and the current through each component in series and parallel circuits. The correct use of the ammeter should be explained.
g) The symbols used to represent the common components of electric circuits should be introduced. Students should draw simple circuit diagrams. *Note:* Problem solving related to series and parallel circuits is not required in this course. It is required in the general-level applied physics and the advanced-level physics courses in Grade 12.
h) Students can use data collected in activity 2g to infer the existence of a magnetic force field around a wire carrying an electric current. It should be emphasized that magnetism can be generated from electricity and vice versa.
i) A microgravity field (one having almost no gravitational effect) exists in a spacecraft. Students might be asked to describe what they would observe if activity 2c, involving iron filings and a magnet, were performed in a spacecraft.

Optional Unit 1

Astronomy

Time: 14 hours

Astronomy is the branch of science that deals with the universe beyond the earth's atmosphere. As a science discipline, it is unique in that it presents an approach to science that is observational rather than (as in most sciences) experimental. This unit emphasizes the direct (as well as the indirect) observation of objects in the sky. All students will be familiar with concepts such as the shape, size, rotation, and revolution of the earth; compass directions; the cause of day and night; and the cause and repetition of the seasons. No other astronomical knowledge is assumed. Perhaps the most important purpose of this unit is to help students appreciate, as Henri Poincaré pointed out, that though their bodies are small, relative to the cosmos, their minds are large enough to contemplate the universe.

This unit may be divided into topics such as the following:

- Motions of the sun and moon
- The solar system
- Beyond the solar system

Note: See the comments on this unit in the subsection "Specific Approaches to Be Considered" (page 8).

1. Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation of the vastness and beauty of the universe and the variety of the objects in it (2a, 2d, 2g-2j);
b) an awareness that astronomy, unlike most other sciences, must develop primarily through observation rather than through experimentation;
c) a realization that statements about the universe represent current knowledge and that some may change as more knowledge accumulates (2i, 2j, 3c, 4b, 4d, 8i);
d) an appreciation of the orderliness of the universe, which can be understood through scientific investigation;
e) an appreciation of the predictability of many astronomical events (2c, 2e, 4b);
f) a curiosity about the universe and the objects in it (4d, 4f, 8a).

Skills. Students will have the opportunity to develop skill in:

a) setting up and keeping a log of their astronomical observations, using appropriate notations, drawings, and charts (2a, 2c-2g, 2j, 8b, 8c);
b) designing, calibrating, and using a sundial as a timepiece (2b, 3a, 3b);
c) using a simple sky chart or planisphere to locate objects in the night sky (2e, 2g, 2j);
d) distinguishing among various objects that are visible in the night sky by means of their appearance and motion (2g, 2j);
e) determining compass directions with the aid of the stars by night and the sun by day (2b, 2e, 2f);
f) illustrating and explaining the phases of the moon by means of a simple model (2c);
g) conducting simple experiments to study certain characteristics of the sun and its light (2k);
h) sharing their observations with other students, particularly those whose individual observations were made at different times and in different places;
i) observing and interpreting photographs of astronomical objects (2d, 2i, 2j);
j) calculating how long it takes for the light from the sun, one or two planets, and one or two stars to reach the earth, given that the speed of light is 3×10^8 m/s (8h).

Knowledge. Students will be expected to:

a) explain the following terms and be able to recognize these objects in the night sky or in photographs: universe, galaxy, star, star cluster, constellation, nebula, planet, satellite (or moon), asteroid, comet, meteor, meteorite;
b) explain the difference between *rotation* and *revolution*;
c) describe the special role that light plays in providing astronomical information;
d) describe the use of the telescope and other astronomical instruments to gather and focus light and to record information based on the light that is incident on them;
e) describe the daily westward motion of the sun and other objects in the sky in terms of the earth's eastward rotation (2e);
f) demonstrate or describe how to determine compass directions with the aid of the stars by night and the sun by day (2f);
g) explain the phases of the moon in terms of its reflection of sunlight and its revolution about the earth (2c);

h) identify and describe the principal features on the surface of the moon, such as mountains, maria, craters, and rays (2d);
i) name the planets of the solar system in order outwards from the sun and describe the arrangement of their orbits in space (2g-2i);
j) list the major or unique characteristics of the sun and each of the planets in the solar system (2i);
k) describe some physical properties of sunlight (2k);
l) identify, through direct observation or by means of a sky chart, certain bright stars and easily recognized star patterns in the sky (2g, 2j).

2. Student Activities

Students are to:

*a) keep, throughout this unit, a log of their astronomical observations (5a, 8b, 8c, 8e);
*b) build, calibrate, and use a simple sundial (5b, 6a);
*c) observe the phases of the moon, record their observations, and use a simple model to describe and explain why the phases occur (3a, 5a, 6b, 8b, 8d, 8f);
*d) (i) observe, with the naked eye, a pair of binoculars, or a telescope, major features on the surface of the moon and record or describe their observations *or* (ii) describe, from observations of photographic prints or slides, the appearance of the planets in the solar system (5d, 6b, 8f, 8k);
e) (i) observe and record the westward motion of objects in the sky (e.g., the rising or setting of the sun or moon) *or* (ii) observe and record the orientation and position of the Big Dipper at approximately the same time of night for different seasons of the year (5a, 6b, 8g);
f) describe how compass directions can be determined with the aid of the stars by night and the sun by day (6a, 6b);
*g) with the aid of a simple sky chart, locate and observe some stars (e.g., Polaris, Sirius, Vega, Betelgeuse, Rigel, Deneb, Altair, Arcturus), some constellations (e.g., the Big Dipper, the Little Dipper, Cassiopeia, Orion, Pegasus, Leo), and any bright planets that are visible in the night sky (5c, 6b);
h) construct a scale model of the solar system, using the same scale, if possible, for the sizes of the sun and planets and the distances between them (8h);
i) using the school library resource centre or other source of information, list some properties of the sun and the planets (5d, 8i, 8j);
j) observe certain types of objects in the sky during the year, including representative examples of stars (e.g., Polaris, Vega, Betelgeuse), star clusters (e.g., the Pleiades), nebulae (e.g., the Orion Nebula), and galaxies (e.g., the Andromeda Galaxy), and record some general information about each type (5a, 6b, 8i, 8j);
k) investigate some physical properties of the sun (a typical star) or its light by doing experiments such as (i) projecting an image of the sun on a screen to observe any sunspots, (ii) using a prism or diffraction grating to disperse the sunlight, and (iii) heating water by solar means (6a).

3. Applications

a) The regular motions of the sun, moon, and stars in the sky have been the basis for the measurement of time for centuries.
b) The positions of objects in the sky have been and are used to determine directions and positions on the earth and are the basis for much navigation.
c) The desire to understand the universe has stimulated the development of instruments such as telescopes and vehicles such as spacecraft.
d) The sun is the primary source of energy for the earth.

4. Societal Implications

a) The study of astronomy has led to the development of the calendar and the dating of events in history.
b) The use of astronomical observations in the prediction of certain events (e.g., floods, seasons, eclipses) has influenced societies on earth for centuries.
c) Astronomy provides an enjoyable leisure-time activity for thousands of Canadians. Also, many careers are related to astronomy and the exploration of outer space.
d) Astronomy provides information about the place of the earth in space and time and encourages speculation about its origin and future. It stimulates the imagination and contributes to a sense of shared exploration and intellectual excitement.
e) People living away from the lights of urban areas can experience the full beauty and wonder of the night sky (e.g., the aurora borealis).
f) An understanding of outer space complements a study of the earth's surface and atmosphere and provides a more complete view of the place of human beings in the universe.
g) Astrology influences some people. The relationship between astronomy and astrology might be treated as a sensitive issue. See section 10, "Values in Science Education", in Part 1 of the guideline.

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* See the subsection entitled "Student Activities" on page 6.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) observations recorded in their logs;
b) construction and calibration of sundials;
c) identification of stars and constellations with the aid of a sky chart;
d) ability to use information from photographs, slides, star maps, and other reference material.

6. Safety Considerations

a) Students should never look directly at the sun, especially when using binoculars or telescopes. They should be informed that the best way to view the sun with a pair of binoculars or a telescope is by projection.
b) Precautions should be taken if students are to observe the sky at night, either at home or at school. Such precautions include the following:
    - Students should not have to travel or work alone in isolated areas.
    - Students should be aware of obstacles and other sources of danger when working in the dark.
    - Teachers should ensure that extension cords that are used outdoors (e.g., for telescopes) are properly grounded.
    - Parents and guardians of students should be informed of any assignments that students are required to do involving the observation of the sky late at night.

7. Possible Extensions

Some students might:

a) visit a planetarium or observatory or attend a meeting of an astronomy club such as the Royal Astronomical Society of Canada;
b) photograph the sky and some of the objects in it;
c) build a planisphere;
d) observe a planet over a period of a month or two in order to trace its motion with respect to background stars;
e) during the school year, observe and record the changes in time and position on the horizon of sunrise and sunset;
f) explain and demonstrate how latitude on the earth may be determined by sighting the North Star;
g) investigate the development of the calendars used by various groups in the past and present (e.g., Chinese, Christian, Islamic, Jewish);
h) investigate the life and work of an astronomer, past or present, or the historical development of our ideas about some aspect of astronomy, such as planetary motions;
i) obtain and summarize information on modern ways of keeping time;
j) read a science-fiction story related to astronomy or outer space and discuss the relationship between science and science fiction.

8. Some Teaching Suggestions

a) This unit highlights some basic astronomical concepts that are not likely to change. Current developments can be dealt with by maintaining a bulletin board. It is important to capitalize on astronomical events or developments, such as eclipses or spacecraft missions, that occur during the year.
b) Students should be encouraged to observe and record in their logs one astronomical object or event each week. Suggestions for these "objects of the week" may be found in astronomy columns in newspapers or other sources. The teacher can focus students' attention on each object by posing a question or two each week and can encourage students to become familiar with many objects in the sky over the course of a year.
c) The organization of students' logs should reflect good scientific observation, an essential skill in a science such as astronomy. The log should have a set format that includes the following: time, location, sky conditions, observer's name. Annotated sketches of observed objects should be included. Questions that arise from each observation should be noted, and class time should be allotted for preparing for out-of-class observations, for reviewing the observations, and for dealing with the questions that arise.
d) If the observations of the phases of the moon are started at the first quarter, the initial observations can be made during class time.
e) Students can be introduced to the appearance of the night sky through a properly supervised "star night" at school or as part of an excursion to an outdoor education centre. Alternatively, they can be given instructions in school on the use of a simple star chart and later carry out assignments at night at their convenience. A visit to a planetarium will provide them with an effective simulation of the night sky.
f) Some activities involving the moon and all activities involving the sun can be carried out during the day.
g) The position of an object in the sky can be specified, relative to the horizon, by giving its rough compass direction and its approximate height above the horizon in "fists", "spans", or degrees.

h) In addition to metric units, such as the kilometre, megametre, and gigametre, astronomers make use of the astronomical unit (AU), that is, the average distance of the earth from the sun, and the light year (LY), that is, the distance travelled by light in one year. It should be noted, however, that measurement is not a major part of this unit. In activity 2h two different scales may be used, one for distances and another for diameters.
i) Astronomy has developed rapidly in recent years, and students should realize that some information (e.g., the number of satellites of the giant planets) found in books may be out of date. The science department and the school library should seek to maintain up-to-date reference material on astronomy.
j) Much useful information on current events and developments in astronomy can be obtained from local science museums, planetariums, newspapers, magazines, and certain television and video programs.

Optional Unit 2

Waste Management

Time: 14 hours

The manufacturing and marketing methods that are common in our society produce large volumes of solid and liquid waste. This unit will introduce students to the different types of wastes and their effects on the environment. The dangers inherent in a "throw-away" society and the techniques and benefits of waste prevention and control are also discussed.

This unit may be divided into topics such as the following:

- Liquid and solid wastes
- Wastes and the environment
- Hazardous wastes
- Waste management

1. Objectives

Attitudes. Students will be encouraged to develop:

a) a concern about the influence of our lifestyle on the quality of the environment (4c, 4e);
b) a respect for the effort and expense required to maintain a quality environment (2f, 3d, 4b-4f);
c) a commitment to the reduction of solid and liquid waste (4b, 4c, 4f).

Skills. Students will have the opportunity to develop skill in:

a) classifying solid household wastes (2a);
b) classifying products according to their packaging (2g);
c) calculating costs of waste management and extrapolating those costs to larger samples (2f);
d) analysing and comparing properties of samples of various plastic materials (2c);

e) reaching conclusions about the effectiveness of floc formation in removing suspended particulates from water (2d);
f) recording information obtained in a survey (2g);
g) taking part in classroom discussions (2g, 2h, 8b, 8f).

Knowledge. Students will be expected to:

a) explain the following terms: open dump, sanitary landfill, incinerator, aerobic, anaerobic, erosion, corrosion, primary and secondary industry, compostable, biodegradeable, recycle, reclaim;
b) name some common household wastes and outline their effects on the environment (2a, 2g);
c) describe methods of disposal for household wastes (2e, 4b);
d) outline methods of reducing household wastes (2g, 4b);
e) name some common industrial wastes and describe how they enter the environment and their effects on the environment (2h, 2i, 3e, 4d);
f) outline methods of managing and reducing industrial wastes (2h, 2i, 3c, 3e);
g) describe the common kinds of waste found in turbid water (2d, 4c);
h) describe the techniques used to purify water (2d);
i) define terms used in hazardous-waste management, such as the following: carcinogen, reactivity, parts per million (see 8i), leachate, organic, inorganic, volatile, tolerance;
j) list the benefits of waste management (3d, 4c-4f).

2. Student Activities

Students are to:

*a) sort and classify the materials in a sample of solid household waste (categories include paper, plastic, metal, glass, and organic material) and further classify each material as "reuse" or "recycle" (5b, 6a);
b) test the effects of water and acidic and basic solutions on several types of oil lubricants, including automobile oil (8g);
*c) test the properties of a number of different household plastic objects or materials (5b, 6b, 6c, 8g, 8h);
*d) do an experiment to show the effects of floc formation on the removal of solid waste from turbid water samples;
e) visit a landfill site, garbage-disposal facility, water-purification plant, or sewage-treatment plant to observe the processing of domestic or industrial wastes (8a);
*f) calculate the cost per person of conventional garbage disposal in their community and extend this exercise to determine the cost per tonne of collecting garbage and estimate the total cost of garbage disposal in Canada (5c, 8a);
*g) do a survey of products in the home to determine those that are overwrapped or double-wrapped; classify the wrappings as paper, cellophane, moulded plastic, or other material, and use the compiled results of the class survey to discuss possible methods of waste reduction (5b, 8a);
h) outline a number of techniques used for controlling hazardous waste in Ontario, including a brief description of each available method for the reduction of hazardous waste and the problems associated with each (8f);
i) use the library resource centre in writing a report on one aspect of waste management or waste disposal, for example, the Love Canal, chemicals in the Great Lakes, sewage disposal in Ontario cities, designated chemicals in Ontario, laws on waste management, or the disposal of hazardous waste (8c-8e).

3. Applications

a) Organic waste has several possible uses. It can, of course, be recycled into the soil through composting. It can also be burned in large furnaces to produce energy for heating buildings or generating electricity.
b) Waste paper may serve as a fuel. It is burned, for example, in kilns to reduce the necessity for burning coal.
c) Steel and aluminum cans can be recycled. It takes a great deal less energy to make new cans from old ones than it does to make new cans from iron or aluminum ores.
d) Completed landfill sites may be converted into recreation areas.
e) Contaminants can be removed from industrial wastes on site and then reused. This on-site recycling is particularly profitable in the electroplating, photofinishing, textile, and paint industries. The silver released from film as it is processed, for example, can be purified in the same plant and used in the manufacture of new film.

4. Societal Implications

a) At present most wastes are deposited in landfill sites. As communities grow, the amount of land available for a dump is reduced, and the cost of transporting waste increases as more distant sites are used.
b) A number of communities and individuals are beginning to invest in recycling on a large and organized scale.
c) The careless dumping of hazardous industrial wastes can severely damage the environment. The Love Canal area in New York State provides an example. The waste dump there threatens the health of the nearby community, and the waste leaks into and contaminates the Niagara River.

* See the subsection entitled "Student Activities" on page 6.

d) The Ontario government has established the Ontario Waste Management Corporation (OWMC). The OWMC must implement a plan for the proper management of industrial wastes in Ontario. The cost of a toxic-waste-management facility is very high, but the long-term cost of maintaining present methods of disposal is also high.
e) Most people recognize the need for a proper waste-management facility to dispose of hazardous wastes, but few people are willing to have that facility located near their own community.
f) By reducing and recycling wastes from the home, people can reduce energy consumption in the manufacturing sector, reduce the cost of garbage collection and treatment, and create a cleaner, safer environment.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) laboratory work and reports;
b) activities to survey, classify, and investigate solid wastes and the packaging of common household items;
c) calculations of the costs of the disposal of wastes.

6. Safety Considerations

a) Students should wear gloves and aprons for sorting waste in activity 2a.
b) Students should wash their hands after any contact with the chemicals used to test the solubility of plastics in activity 2c.
c) Small plastic samples should be used for activity 2c, and adequate ventilation should be provided when the samples are burned.

7. Possible Extensions

Some students might:

a) study the chemicals known as "designated" under the Ontario Occupational Health and Safety Act and investigate the reason for the designation, the hazard, the uses of those chemicals in industry, and the methods of their disposal;
b) study some of the sources of, effects of, and controls on gaseous wastes that are released into the environment;
c) study the dumping of warm water into natural waterways by power plants and the effects of this practice on aquatic life;
d) investigate the dangers inherent in transporting radioactive wastes and the methods used to dispose of these wastes;
e) do a comparative cost analysis of recycled versus new paper;
f) do a case study based on a single industry in Ontario to focus attention on the waste problem. The dry-cleaning industry would be a good example, since it uses a potentially hazardous organic solvent (carbon tetrachloride or its derivatives) in its cleaning process. Students can investigate the quantity of chemical used, its effects on humans, its cost, the amount entering the atmosphere, and the methods used to dispose of excess or waste chemicals.

8. Teaching Suggestions

a) Excursions or assignments that may be completed in or out of school should be used to draw attention to the quantity of waste we produce. If a visit (suggested in activity 2e) is impractical, a report on a local facility might be studied.
b) In this unit a great deal of the learning should result from discussion and assignments stimulated by magazine or newspaper articles. Students should make a scrapbook or organize a classroom bulletin board using articles on waste management.
c) The Ontario Waste Management Corporation provides a variety of teaching aids and information on waste processing, including a video cassette and a board game.
d) The fact sheets published periodically by the Ontario Ministry of the Environment provide material for case studies or discussion.
e) The Department of Energy, Mines and Resources and Atomic Energy Canada, both in Ottawa, can supply additional information on wastes and waste processing.
f) Activity 2h can be done as a class project, with small groups working on a single type or kind of waste and the strategies for its control. Information can then be shared.
g) Activities 2b and 2c should be used to demonstrate the resistance of oils and plastics to decomposition in the environment.
h) The small samples of plastic in activity 2c could be tested for colour, transparency, flammability, hardness, elasticity, flexibility, brittleness, and solubility in water, alcohol, sodium hydroxide, hydrochloric acid, and sulphuric acid.
i) When ratios are expressed in parts per million, care should be exercised to use up-to-date editorial practice. See Appendix C, subsection 22, in Part 1 of the guideline.

Optional Unit 3

Science Project

Time: 14 hours

This unit is the same for the Grade 10 advanced-level science course as optional unit 2, "Science Project", is for the Grade 9 advanced-level course. Students who have done a science project in a previous grade should, of course, choose a different project for this course.

Optional Unit 4

Locally Designed Unit

Time: 14 hours

This unit is the same for the Grade 10 advanced-level science course as optional unit 3, "Locally Designed Unit", is for the Grade 9 advanced-level course. A different set of topics from those selected in a previous grade should, of course, be selected for this course.

Appendixes

Appendixes

A. Science Courses and Their Course Codes
B. The Table of Contents of Part 1

Appendix A

Science Courses and Their Course Codes

The secondary school guideline courses in science authorized under this document have the following course codes:

Science, Grade 9, Basic Level	SNC1B
Science, Grade 9, General Level	SNC1G
Science, Grade 9, Advanced Level	SNC1A
Science, Grade 10, Basic Level	SNC2B
Environmental Science, Grade 10, General Level	SEN2G
Science, Grade 10, General Level	SNC2G
Environmental Science, Grade 10, Advanced Level	SEN2A
Science, Grade 10, Advanced Level	SNC2A
Science, Grade 11, Basic Level	SNC3B
Applied Biology, Grade 11, General Level	SBA3G
Applied Chemistry, Grade 11, General Level	SCA3G
Environmental Science, Grade 11, General Level	SEN3G
Biology, Grade 11, Advanced Level	SBI3A
Chemistry, Grade 11, Advanced Level	SCH3A
Science, Grade 12, Basic Level	SNC4B
Environmental Science, Grade 12, General Level	SEN4G
Geology, Grade 12, General Level	SGE4G
Applied Physics, Grade 12, General Level	SPA4G
Environmental Science, Grade 12, Advanced Level	SEN4A
Geology, Grade 12, Advanced Level	SGE4A
Physics, Grade 12, Advanced Level	SPH4A
Technological Science, Grade 12, General Level	STE4G
Biology, OAC	SBI0A
Chemistry, OAC	SCH0A
Physics, OAC	SPH0A
Science in Society, OAC	SSO0A

The following general rules govern science course codes:

- All science course codes begin with an **S.**
- **SNC** identifies a course that has only the name "Science".
- Where one word other than "Science" describes the course, the first two letters of that word follow the **S** (e.g., **SBI** means "Science, Biology" or simply "Biology"; **SEN** means "Science, Environmental" or "Environmental Science").
- Where two words other than "Science" describe the course, the initial letters of those words are used (e.g., **SCA** means "Science, Chemistry Applied" or simply "Applied Chemistry").
- The fourth character in the course code, **1**, **2**, **3**, **4**, or **0**, represents Grade 9, 10, 11, 12, or an OAC respectively.
- The fifth character represents the level of difficulty: **B** for basic, **G** for general, or **A** for advanced.

For further information on course codes, refer to the *Manual for the Common Course Code* (Toronto: Ministry of Education, Ontario, 1986).

Appendix B

The Table of Contents of Part 1

Preface
Introduction
  The Parts of the Guideline
  Guideline Courses
  Superseded Guidelines

A. Goals and Aims

1. The Value and Purpose of Science Education
2. The Goals of Education and the Role of Science
3. The Aims of the Science Curriculum
  3.1 The Aims
  3.2 The Nature of Science
  3.3 Scientific Literacy
  3.4 Curriculum Emphases – Blending Curriculum Aims With Content

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B. Science Program Framework

4. Science Courses
  4.1 The Science Continuum From Kindergarten to OACs
  4.2 Levels of Difficulty: Basic, General, and Advanced
  4.3 Science Courses and Credits
  4.4 Units of Study Within Each Course
  4.5 Recommendations Regarding Course Selections
5. Teaching Policy
  5.1 Content and Process
  5.2 Components in Each Unit of Study
  5.3 Teaching Policy for All Science Units
  5.4 Time Allocations for Each Unit
  5.5 Locally Designed Units
  5.6 The Grade Placement and Naming of Local Science Courses
  5.7 Overall Policy for Science Courses

C. Special Features of the Science Program

6. Considering the Science Student
  6.1 The Image of the Successful Science Student
  6.2 Program Adaptations for Exceptional Students
  6.3 Individualized Instruction
  6.4 Life-Management Skills
  6.5 Employment Awareness
  6.6 Sex Equity
  6.7 Multiculturalism
7. Language and Science
  7.1 Language Skills
  7.2 Assignments and Evaluation
  7.3 English Vocabulary in French-Immersion Science Courses
  7.4 Immigrant Students
8. Measurement
  8.1 Estimation
  8.2 Metric Units and Physical Quantities
  8.3 Accuracy and Precision
  8.4 Formats in Solutions to Problems
9. Safety
  9.1 Safety in the Laboratory
  9.2 Some Recommended Safety Procedures
  9.3 Animal Care in Science Courses
  9.4 The Safe Use of Plants

10. Values in Science Education
    10.1 The Role of Values Issues in Science Courses
    10.2 Handling Sensitive Issues

D. Implementation

11. Curriculum Planning and Staff Development
    11.1 Policy Planning at the Board Level
    11.2 Program Planning at the School Level
    11.3 Course Planning at the Teacher Level
    11.4 School-Board Curriculum Documents
    11.5 Staff Development
12. Resources
    12.1 Science Laboratories and Equipment
    12.2 Library Resource Centres
    12.3 Textbooks and Learning Materials
    12.4 Calculators
    12.5 Computers
    12.6 The Scientific Community
13. Modes of Delivery
    13.1 Bilevel and Multigrade Classes
    13.2 Co-operative Education
    13.3 Program Packages
    13.4 Adult Education
    13.5 Independent Learning Centre
    13.6 Specialized Schools
14. Evaluation
    14.1 Evaluating Guideline-Implementation Progress
    14.2 Evaluating Student Achievement
    14.3 Self-Evaluation of Teacher Performance
    14.4 Evaluation of Program Effectiveness

Appendixes

A. Science Courses and Their Course Codes
B. Physical Quantities
C. Metric Editorial Practice
D. Some Poisonous Plants
E. Some OAIP Instrument Types and Learning Domains

87-046

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